TRAFFIC DETECTORS

were and the

Instructor Manual



Federal Highway Administration

INTRODUCTION

This notebook provides guidance to the instructor in preparing for and making course presentations. It presents this guidance in the form of:

- o Course concept and objectives
- o Course agenda
- o General suggestions on teaching techniques and the presentation environment
- o Specific guidelines for each session
- o Course evaluation form

Much of the course material is extracted from the Traffic Detector Handbook, therefore the instructor should be familiar with the Handbook content. It should be assumed that many of the course participants will have read selected portions of the Handbook.

Course Concept and Objectives

This course on Traffic Detectors is designed for highway/traffic engineers and technicians who have responsibility for designing, installing and maintaining magnetometers, magnetic detectors and inductive loop detectors. At the completion of the course the participants should have greatly enhanced their ability to do the following for magnetometers, magnetic detectors and inductive loop detectors:

- o Understand the basic principals of detector theory.
- o Develop an understanding of detector applications.
- Understand basic procedures and techniques for installing detectors.
- o Understand the basic procedures for maintaining detectors.
- o Develop an understanding of the operation and characteristics of detectors through hands-on experience at the fifteen (15) workshop stations.
- o Develop a common vocabulary of the different elements of each detector type.
- o Understand the basics of detector specifications.

Course Agenda

The course is divided into six topics, each indicating a broad area of instruction. Each topic is treated in one or more sessions with each session being a specific instructional unit presented by a single instructor. There are fifteen (15) workshop sessions in the course. Each workshop session will provide the participant an opportunity to handle some detection equipment and run through some specific exercises that are documented at each station. This will help the participant to gain a better understanding of theory, applications, installation and maintenance techniques which will be presented through the training course.

The agenda presents the order in/which the topics are to be covered and indicates the approximate amount of time to be devoted to each subject. The topics are arranged so that some basic information is presented at the beginning, before the workshop sessions begin, to give the participant some basic information that he will need during the workshop sessions.

The overall three day format should be maintained. To accommodate travel by participants and instructors, the three day course should commence on Tuesday and end on Thursday. Each session should begin and end at the times specified on the schedule. This will be especially important during the workshop stations because the participant will be tempted to continue to play with the equipment beyond the scheduled time.

Schedule of Activities

| Day and Time | Session No. | Topic/Session Title |
|--------------|-------------|--|
| TUESDAY | 1 | Introduction |
| 8:00-8:30 | | Registration |
| 8:30-9:00 | | Welcome, Introduction of Participants and Instructors, Scope of Course |
| 9:00-9:20 | | Purpose and History of Detectors |
| 9:20-9:50 | | Film "Loop-Occupancy Control" |
| 9:50-10:10 | | Break |
| 10:10-11:30 | 2 | Detector Theory and Hardware |
| | | Inductive Loop Detectors |
| 11:30-12:30 | | Lunch |
| 12:30-2:00 | | Detector Theory and Hardware |
| | | Inductive Loop Detectors, cont. |
| | | Magnetometers & Magnetic Detectors |
| 2:00-2:15 | | Break |
| 2:15-3:15 | 3 | Orientation to Workshop Sessions |
| 3:15-3:30 | | Break |
| 3:30-4:00 | 4 | Workshop No. 1 |

Schedule of Activities

| Day and Time | Session No. | Topic/Session Title | | | | |
|--------------|-------------|---|--|--|--|--|
| WEDNESDAY | | | | | | |
| 8:00-9:00 | 5 | Loop-Detector Installation | | | | |
| 9:00-9:30 | 6 | Workshop No.2 | | | | |
| 9:30-10:00 | 7 | Magnetometer Installation | | | | |
| 10:00-10:30 | 8 | Workshop No. 3 | | | | |
| 10:30-11:00 | 9 | Magnetic Detector Installation | | | | |
| 11:00-11:30 | 10 | Workshop No. 4 | | | | |
| 11:30-12:30 | | Lunch | | | | |
| 12:30-1:00 | 11 | Fine Points of ILD Theory and Hardware | | | | |
| 1:00-1:30 | 12 | Workshop No. 5 | | | | |
| 1:30-2:00 | 13 | Detector Applications at Signalized Intersections | | | | |
| 2:00-2:30 | 14 | Workshop No. 6 | | | | |
| 2:30-3:00 | 15 | Detector Applications at Signalized Intersection | | | | |
| 3:00-3:30 | 16 | Workshop No. 7 | | | | |
| 3:30-4:00 | 17 | Detector Applications at Signalized Intersections | | | | |

Schedule of Activities

| Day and Time | Session No. | Topic/Session Title | | | | | |
|--------------|-------------|---|--|--|--|--|--|
| THURSDAY | | | | | | | |
| 8:00-8:30 | 18 | Workshop No. 8 | | | | | |
| 8:30-9:00 | 19 | Detector Applications: Other Local Applications | | | | | |
| 9:00-9:30 | 20 | Workshop No. 9 | | | | | |
| 9:30-10:00 | 21 | ILD Maintenance | | | | | |
| 10:00-10:30 | 22 | Workshop No. 10 | | | | | |
| 10:30-11:00 | 23 | Magnetometer & Magnetic Detector Maintenance | | | | | |
| 11:00-11:30 | 24 | Workshop No. 11 | | | | | |
| 11:30-12:30 | | Lunch | | | | | |
| 12:30-1:00 | 25 | Workshop No. 12 | | | | | |
| 1:00-1:30 | 26 | Course Evaluation/Critique | | | | | |
| 1:30-2:00 | 27 | Workshop No. 13 | | | | | |
| 2:00-2:30 | 28 | Detector Specifications | | | | | |
| 2:30-3:00 | 29 | Workshop No. 14 | | | | | |
| 3:00-3:30 | 30 | Discussion of Detectors | | | | | |
| 3:30-4:00 | 31 | Workshop No. 15 Certificates | | | | | |

NOTES TO THE INSTRUCTORS

Technique

Three days is a long time to be a course participant. It is essential that the instructors focus continuously on maintaining participant interest and combating boredom. The single most effective way to do this is to solicit and encourage questions and comments from the participants. If there are no questions or comments, the lectures could just as well be taped. Most participants will have valuable information to contribute from their own experience if they can be enticed to offer it.

A good informal question and answer environment does not occur automatically. It must be nurtured and developed. A good way to create the environment is to ask an occasional question of the participants, also to solicit their questions even to the point of making a very controversial statement to elicit discussion. Once the questions begin to flow, treat each one with utmost courtesy. A surly response to a "sharpshooter" will shut off all participants.

Each question should be answered when it occurs or specifically deferred to a more appropriate session. If you do defer a question, tell the questioner why you are deferring and during which session the question will be handled. Then, write the question down so you don't forget about it.

If you do not know the answer to a question say so, don't bluff. The questioner may be laying a trap and a credibility gap created on Tuesday is hard to live with until Thursday.

Another technique for combating boredom is an occasional change of medium. Use a chalk board or a felt pen and flip-chart paper to illustrate some ideas or to respond to some questions. You can also prepare a chalk board, before a session, with the new terminology to be covered then check off the terms as they are defined. This provides a good session wrap-up guide suggesting comment on any terms that were missed or glossed over.

Do not read your notes to the participants. Also, do not read the material on the slides to the participants. Rather, use the textual slides as "jumping off places" for elaboration and extension.

Try to work in a few jokes or witty sayings, but don't use your best jokes on Tuesday. Wait until everyone is comfortable in the course environment which should be by sometime Tuesday afternoon or Wednesday.

Use a slide change extension cord to control your own slides. Nothing is more tedious than the repeated use of "next slide please".

Make sure that the room is dark enough for the slides to be clear but light enough that you can see the participants and they can see you. Eye contact is essential to maintaining interest. These lighting demands are in conflict but they must both be accommodated. The method of accommodation is discussed in the next section of this notebook.

Try to keep track of your time so that you don't get too far behind in your presentation. However, if you do get behind, don't skip material (a later session may need that groundwork) and don't cut off questions. Rather try to make up the time as best you can during the following sessions.

If you get too far ahead, try to develop discussion to get back on schedule. If the first few sessions finish early, the participants will think this is the standard procedure and will resent later sessions which use their full time. The specific guidelines for many of the sessions suggest discussion questions which you can pose as part of your time management technique.

Shortly before your session, check one more time to be sure that your slides are in the right order and project right side up. It is difficult to lecture gracefully from an upside down slide.

This course includes fifteen (15) workshop stations. These stations should be set-up on the day before the course begins. All the equipment is marked in the trunks and photographs are included which shows how each station is to look when it is properly set-up. Be careful when taking the equipment out of the trunks. Keep each foam layer in its proper trunk so that repacking will be easy.

It is EXTREMELY IMPORTANT that the electrical outlets are inspected before the detectors are plugged in. To check the outlets, use the Simpson volt-ohm meter. Set the meter for "AC" and 250v; put black wire to (-) common and red to (+). Place the red lead to short side of plug and black lead to ground. The reading should be midway on the scale. If it is not, the wall outlets should be rewired. DO NOT PLUG DETECTORS INTO WALL OUTLETS THAT DON'T PASS THIS TEST. A yellow plug tester is also included. Follow the directions on the device to determine if the wall outlets are wired properly.

Photographs are included for each trunk to show how each has been designed to be packed. Follow these photos carefully. Don't rush through the packing procedure. Most of the trunks have custom cut foam liners. Each piece of equipment has a specific location in a trunk so don't try to make something fit which doesn't look right. Follow the photographs carefully and there should not be any problems.

Environment

During the registration period give everyone a name tag. Have someone assigned to letter the tags and cards to insure that they will be legible. If there is an advance roster most of the tags can be made ahead of time.

Participants should be seated at tables so that they have room for their participants notebooks, and handouts. Tables must be arranged so that everyone is close enough to read the slides. If there are a large number of participants or if the room is long and narrow, the solution is an extra large screen.

The workshop sessions include demonstrating equipment at fifteen stations which will require at least eighteen (18) tables and preferably twenty (20) tables. The tables should not have metal reinforcing, as this will interfere with the detectors at each station. Fifteen (15) additional tables (2' x 6') should be provided for the participants to sit at during the lecture. A sufficient number of chairs are required for each student to sit at his table during lecture and at a work station, therefore sixty chairs are required.

It is advantageous to be able to present the course in one room. The room should measure at least forty (40) feet by forty (40) feet, preferably fifty (50) feet by fifty (50) feet. At least six to eight electrical outlets are required to provide sufficient electricity for the work stations.

Some instructors have soft voices, thus microphones and speakers must be available. A lapel microphone is far superior to a podium microphone because it allows mobility. If you must use a podium microphone be sure to talk toward the microphone not toward the screen.

If the lighting system in the room does not allow the lights near the screen to be turned off while the other lights are left on:

- Remove the lights from the fixtures near the screen, or
- Turn off all lights but scatter table lamps or floor lamps about the room for illumination.

It is very important that the participants and the instructors be able to see each other.

Provide pencils and scratch pads.

Start the Tuesday afternoon session right on time. This will set the lunch break standard for the rest of the week.

Each session uses 35mm slides as visual aids. Be sure to have an appropriate projector and the largest screen available. It would also be prudent to have a back-up projector or at least an extra bulb. Additionally a 16mm sound movie projector will be required on Tuesday morning and a VCR for Tuesday.

INSTRUCTOR GUIDELINES FOR COURSE INITIATION

A 30 minute registration period begins at 8:00 am. Have someone assigned to make name tags for the participants. Try to meet many of the participants during this period.

At 8:30 the course will be kicked off by welcoming remarks from a representative of the sponsoring agency. These remarks should be cordial and brief (less than 15 minutes).

You should then introduce yourself and the other instructors. You should then ask each participant to introduce himself and give a brief summary of his background experience and present responsibilities. This is an important procedure because it will allow you to identify interest areas and experience reservoirs to be utilized during the course. It will also provide the participants with some insight about their classmates.

At this time you should call attention to the course materials. Ask participants to wear their name tags. Introduce the participant notebook and identify the various parts. Briefly discuss:

- The organization of the Student Manual
- The notepaper in the back of the book
- The instructor bio-data sheets
- The course agenda emphasizing the importance of the topic sequence.

Finally, call attention to the evaluation form, indicate that the participant critique is sincerely desired and that future presentations will be improved by their recommendations. Ask the participants to use the evaluation sheets as the course proceeds rather than waiting until Thursday.

The introduction of participants, instructors and course materials should take 30 minutes.

Course Evaluation

The course evaluation should be conducted at 1:00 during session No. 26 so that all the participants will still be present. A representative of the sponsoring agency should conduct this Session. Two written evaluation forms are included in the Instructor and Student Manuals. The agency representative should invite suggestions and discussion on the course objectives and their attainment and on the course content. The representative should then ask each participant to complete the course evaluation form in the back of the Student Manual.

Finally, the representative should present a course completion certificate to each participant and thank everyone for attending during Session No. 31, Workshop No. 15. The course should be adjourned by 4:00 p.m. at the latest.

EVALUATION FORM FOR TRAFFIC COURSE

| follows: | |
|---|---|
| l. Poor | |
| 2. Well Below Average | |
| 3. Below Average | |
| 4. Average (Acceptable) | |
| 5. Good | |
| 6. Very Good | |
| 7. Excellent | |
| Please circle the number which reflects your rating. | |
| Overall Course Evaluation | |
| 1. Please rate the overall course on its value and significance to you. | |
| 1 2 3 4 5 6 7 | |
| Poor Average Excellent | |
| | |
| Were the stated objectives of the course achieved? | |
| Very well Reasonably Well No | |
| 3. The length of the course was: | |
| Much Too Long Too Long About Right | |
| Much Too Long Too Long About Right Short Very Short | |
| 4. Should additional topics be covered?YesNo | |
| Comments | |
| Comments | |
| | _ |
| 5 OL 11 | |
| 5. Should some topics be reduced or eliminated? Yes No | |
| Comments | |
| | |
| | |
| | |
| | • |

Several items will be rated on a scale ranging from 1 to 7 and defined as

| 6. | For the intended participant, the | e level of technical detail was: |
|------|--|--|
| | Far Too Detailed To About Right A Much Too General | Do DetailedLittle General |
| Соп | nments | |
| | | |
| 7. | Will you, or an associate find th | e textbook of value as a reference? |
| | | |
| | | |
| 8. | Describe any changes you would ma including adding or dropping topi | ke in technical content of the course, cs and level of detail. |
| | | |
| **** | | |
| 9. | Describe any changes you would ma course, including schedule and vi | ke in the educational aspects of the sual aids. |
| | | |
| | | |
| 10. | . Which specific topic(s) was of g | reatest value to you? Why? |
| | | |
| | | |
| | | |

| | | | | topic(| W | <u>-</u> | | | | | | · |
|-----|------|-------|-------------|---------|-------------|----------|--------|--------------|------|--------|-------|------|
| 12. | What | types | of | persons | can b | est | benefi | t from | m th | nis co | urse? | |
| | | | | | | | | , | | | | |

(Circle one for each category)

1 = Poor 2 = Below Average 3 = Average

4 = Good 5 = Excellent

| | MATERIAL | PRESENTATION | VISUAL AIDS |
|---|-----------|--------------|-------------|
| Training Sessions | | | |
| Session 1: Introduction | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 |
| Session 2: Detector Theory and Hardware | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 |
| Session 3: Orientation to Workshop Sessions | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 |
| Session 5: Loop Detector Installation | 12345 | 1 2 3 4 5 | 1 2 3 4 5 |
| Session 7: Magnetometer Installation | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 |
| Session 9: Magnetic-Detector installation | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 |
| Session 11: Fine Points of ILD Theory and Hardware | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 |
| Session 13: Detector Applications at Signalized Intersections | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 |
| Session 15: Detector Applications at Signalized Intersections | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 |
| Session 17: Detector Applications at Signalized Intersections | 12345 | 1 2 3 4 5 | 1 2 3 4 5 |
| Session 19: Detector Applications: Other Local Applications | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 |
| Session 21: ILD Maintenance | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 |
| Session 23: Magnetometer & Magnetic Detector Maintenance | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 |
| Session 26: Course Evaluation | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 |
| Session 28: Detector Specifications | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 |
| Session 30: Discussions of Detectors | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 |
| Workshop Sessions | | | • |
| Workshop Station #1 | 1 2 3 4 5 | 1 2 3 4 5 | 12345 |
| Workshop Station #2 | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 |
| Workshop Station #3 | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 |
| Workshop Station #4 | 12345 | 1 2 3 4 5 | 1 2 3 4 5 |
| Workshop Station #5 | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 |
| Workshop Station #6 | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 |
| Workshop Station #7 | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 |
| Workshop Station #8 | 1 2 3 4 5 | 1 2 3 4 5 | 12345 |
| Workshop Station #9 | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 |
| Workshop Station #10 | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 |
| Workshop Station #11 | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 |
| Workshop Station #12 | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 |
| Workshop Station #13 | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 |
| Workshop Station #14 | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 |
| Workshop Station #15 | 1 2 3 4 5 | 1 2 3 4 5 | 1 2 3 4 5 |

EQUIPMENT INVENTORY

TRUNK #1:

Station 1:

- 1. 2-Detector Amplifiers
- 2. 2-Tonka Trucks
- 3. 3-Magnetic Detectors Probes - 2 which are hooked up for operation
- 4. MKA magnetic detector
- 5. Metal housing for magnetic detector

TRUNK #2

Station #2:

- 1. 2-blue cased MM-9 analyzers
- Canoga Model P202, 2-channel magnetometer detectors,
- 2-double deck roadways,
- 2-harness systems,
- 1-horseshoe shaped magnet,
- 6. 1-meter stick.

TRUNK #3:

Station #3:

- 1. 2-Sarasota 235-T Detector Units
- 2. 2-harness systems,
- 2-Greyhound buses,
- 2-roadways with multi-turn loops,
- 2-green jumper wires,

Station 4:

- 2-roadways with multi-turn loops,
- 2. 2-toy cars,
- 2-Sarasota 516-T detectors,
- 4. 2-Sarasota Bench Test Loops,
- 5. 2 Harnesses, with dual bulb indications,

Station #9:

- 1. 2-Detector System Model #813, traffic detectors
- 2. 2-Single bulb harnesses,
- 3. 2-Roadway models with multi-turn loops,
- 4. 2 toy cars
- 5. 2 jumper clips

TRUNK #4:

Instructors Station:

- Sarasota 235-T/MS Detector,
- 2. Sarasota Bench Test Loop,
- 3. Model Roadway,
- 4. Detector System, Model 813 Detector,
- 5. Toy car,
- 6. Harness and plug system with one bulb.

Station 5:

- 1. Canoga, Model P402-2T Detectors,
- 2. 2 Model Roadways,
- 3. 2 Decator Sensitivity Detectors, which are wood finish,
- 4. Single power cord harness system with 2 bulbs,
- 5. 2 Toy cars,
- 6. 2 Separate harnesses for the Decator Sensitivity Testers,
- 2 Stop Watches.

Station 6:

- 1. 2 Canoga 402-2T toogle switch, 2-channel loop detectors,
- 2 Grey Decatur Sensitivity Testers, with the metal plates simulating wire mesh in the roadway,
- 2 Harnesses for the Decatur Sensitivity Testers, Model DST-300,
- 4. 2 Two light socket harness system with one power plug,
- 5. 1 Toy car,
- 6. 1 Toy bus,
- 7. 2 Jumper cables.

TRUNK #5:

Station #7:

- 2 3M/Canoga P304 Detectors,
- 2. 2 Toy cars,
- 3. 2 Harnesses, each having two bulb socket connections,
- 4. 2 White jump clips,
- 5. 4 Model Roadways.

Station #8:

Same equipment as in Station #7, with the addition of:

2 - 150 TECO PICOFARAD Capacitors

TRUCK #6:

Station 10:

- 2 ICC Digital Loop Detectors,
- 2. 2 Sarasota Bench Test Loops,
- 3. 2 ICC Model 3800 Digital Loop Detectors
- 4. 2 Jumper wires
- 5. 2 Harnesses and power cords for the detectors
- 6. 2 Red and black wires and clips to be attached to the loop tester.

Station 11:

- 1. 2 Decatur XLMH Detectors
- 2 Decatur Sensitivity Testers, and harness to connect the detector with the tester,
- 3. 2 Jumper wires,
- 4. 2 15,000 PF = 624 feet of lead-in,
- 5. 2 7,500 PF = 312 feet of lead-in,
- 6. 2 22,000 PF = 719 feet of lead-in,
- 7. 2 150 PICOFARAD Capacitors for the 3M Drift Test

TRUNK #7:

Station 12:

- 1. 2 Sarasota 215B single channel Calif. model detectors,
- 2. 2 Sarasota Bench Test Loops,
- 2 Single bulb harnesses with power cord and plug,
- 4. 2 3M Drift Test, with 150 PICOFARAD Capacitance,
- 5. 2 917 foot lead-in, with 22,000 PF,
- 6. 2 624 foot lead-in, with 15,000 PF,
- 7. 2 312 foot lead-in, with 7,5000 PF,
- 8. 2 1,000 foot lead-in = 220 microhenries.

Station 13:

- 1. 2 Sarasota 215B Detectors,
- 2. 2 sets 3M/Canoga, 701 micro-loop probes,
- 2 stands for the probes,
- 2 Tonka trucks.

Station 14:

- 2 Sarasota 515T digital single channel detectors,
- 2 Single bulb harnesses, with power cord and plugs,
- various samples heavy duty wire, including detect-a-duct, and signal-duct, and pyro tennex, metal sheath, mineral-insulated cable.

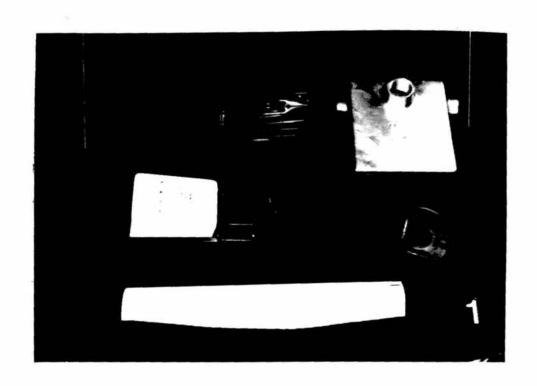
TRUNK #8:

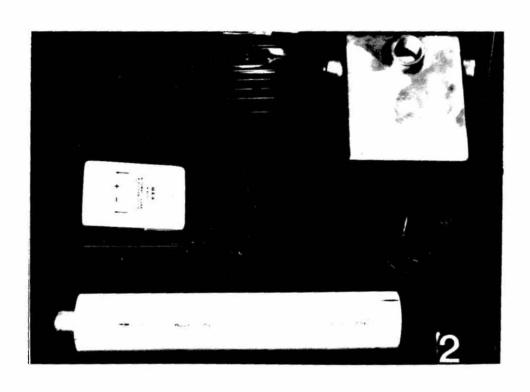
Station 15:

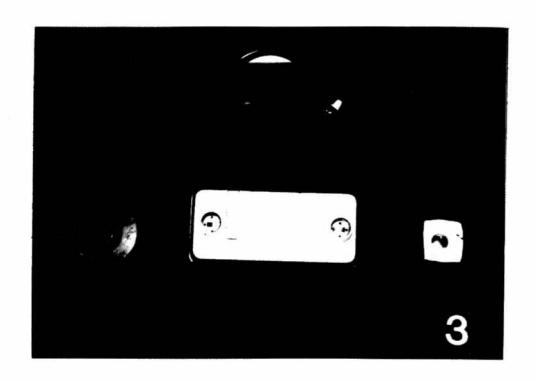
- 2 Decatur loop analyzers, Model DLT-150,
- 2 Saftran loop test meters, Model LT-350,
- 1 Volt/Ohm meter, Simpson Model 260-analog,
- 1 Volt/Ohm meter, Beckman Model 300-digital, 4.
- 5. Misc. materials:
 - 5 power mate cord reels,
 - 1 diamond sawblade,
 - 1 abrasive sawblade,
 - 2 canisters of precoe goldflex loop sealants,
 - 1 3M splicing kit,
 - 1 3M loop sealant caulking gun,
 - 1 Georgia Tech. Movie "Loop Occupancy Control",
 - 1 Manila envelope of various loop wires and splicing materials,
 - 1 Misc. toolbox, which includes splicing crimp equipment, screwdrivers, pliers, batteries, various clips, bute connectors, capacitors, glue sealants, soldering iron, solder, extension cord.

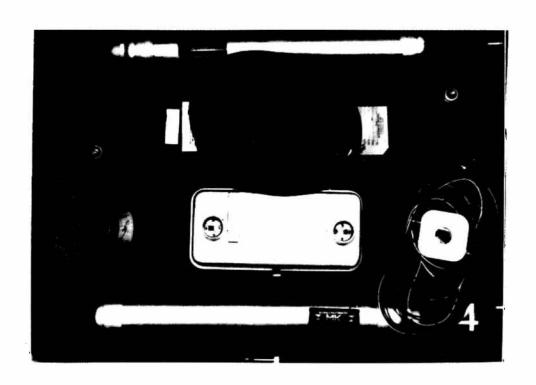
TRUNK #9

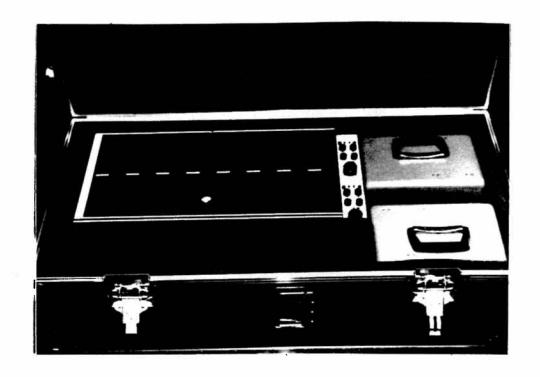
- 4 Collapseable performed loops,
- 1 drill-bit, 2.
- 3. 1 - PVC pipe bend,
- 4. 1 Kodak Carousel 5200 projector,
- 5. l - lens,
- 1 vehicle semulator,
- 6 slide trays for the presentation,
- 8. 1 group of station numbers,
- 1 set of name tags for the desks,
- 10. l Manila envelope: pin-on name tags,
 11. 3 Manila envelopes: material on the equipment,
 - 1 ICC performed loop 5 x 5 with 4 turns.

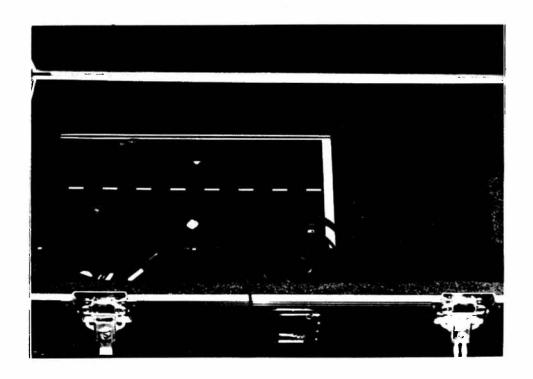


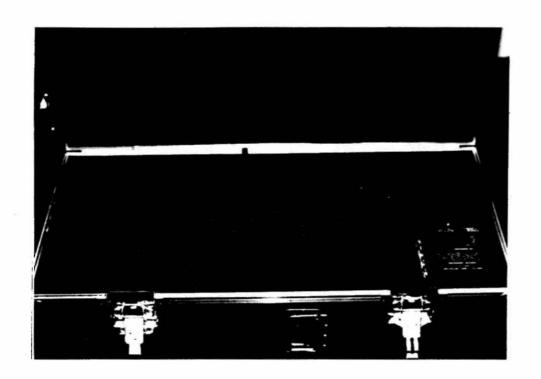


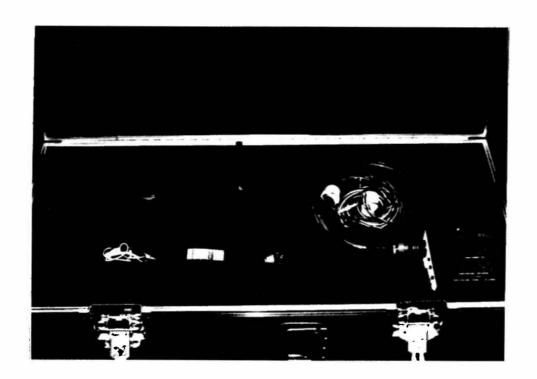




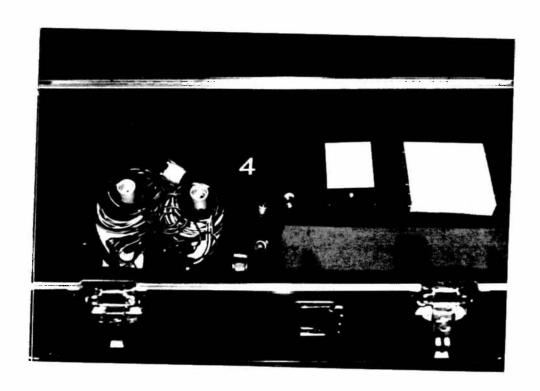




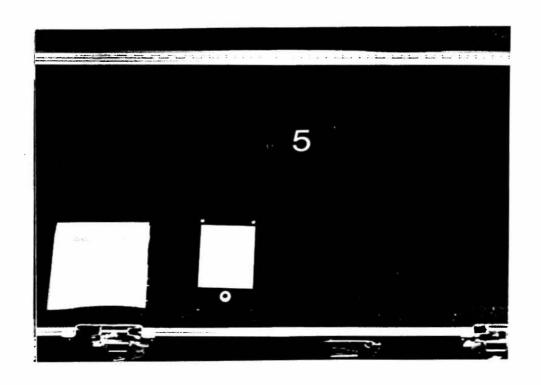


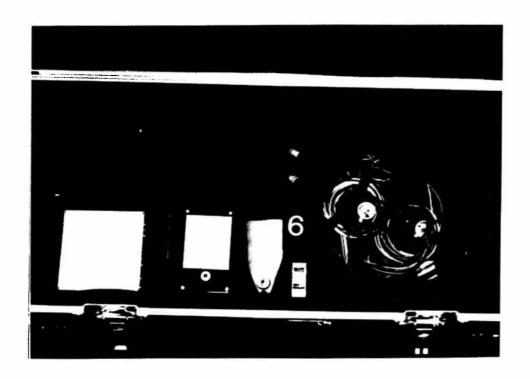


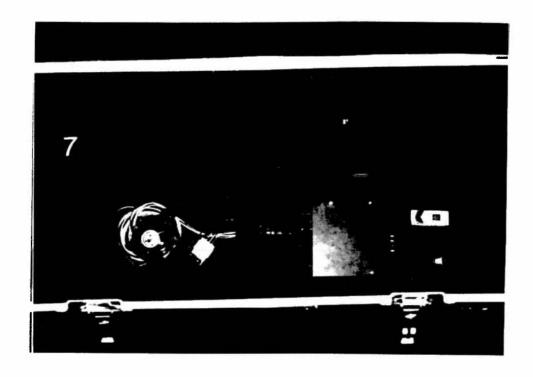


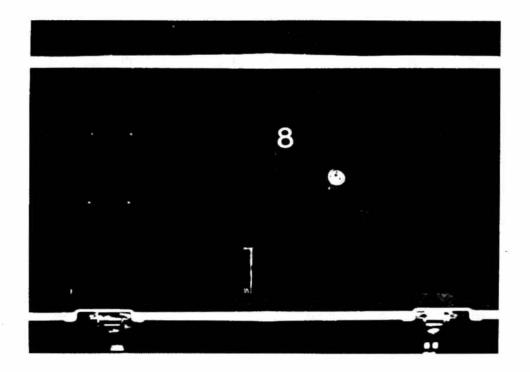


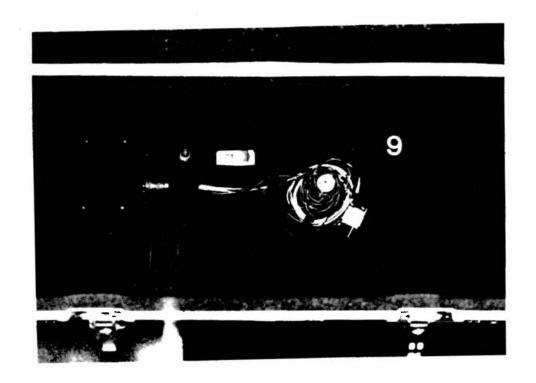
PACKING PROCEDURES FOR TRUNK NO. 3

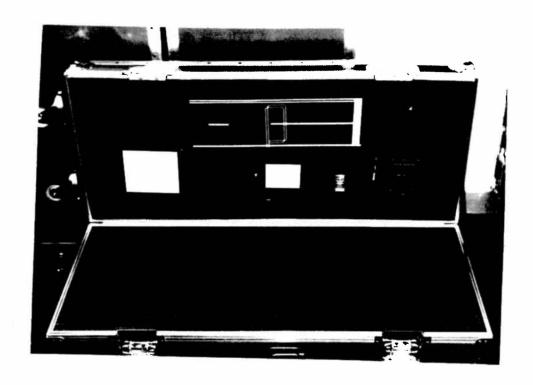


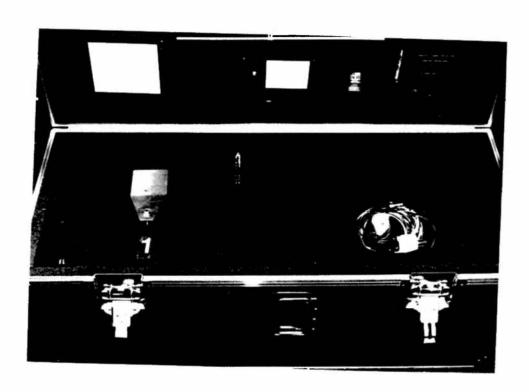




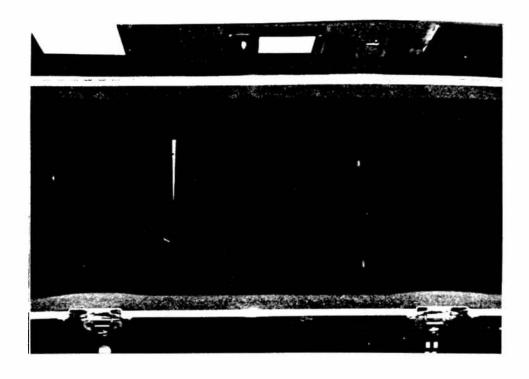


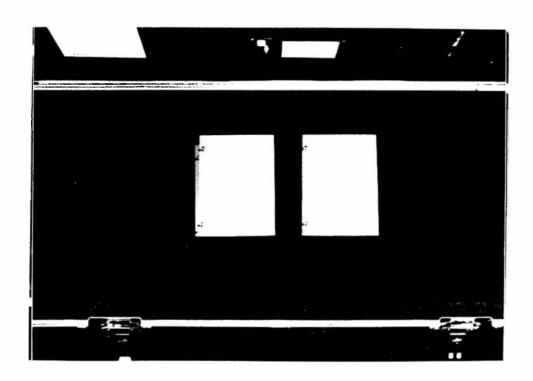


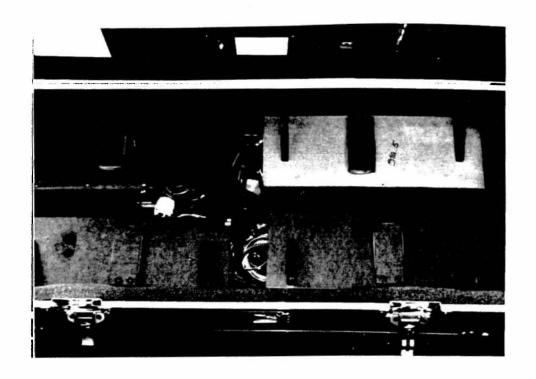


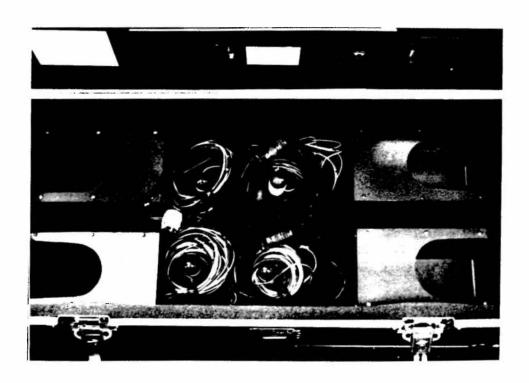


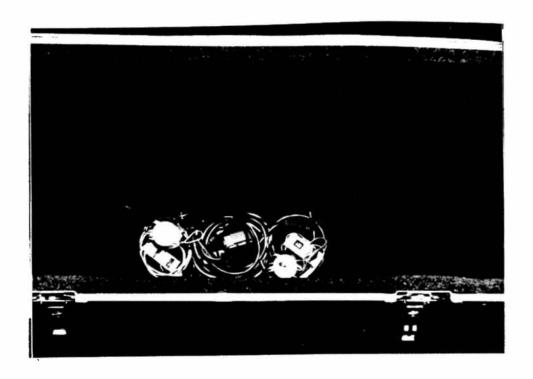
PACKING PROCEDURES FOR TRUNK NO. 4

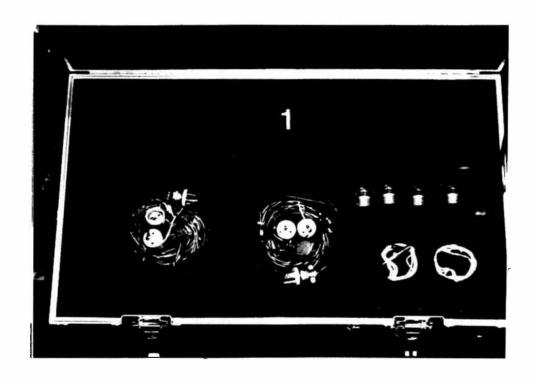


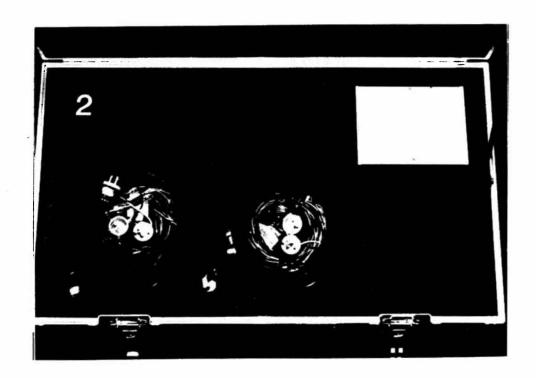


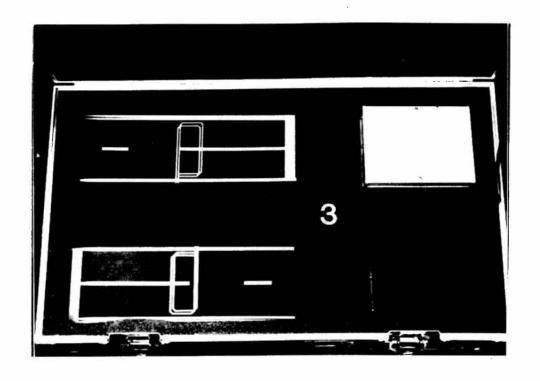


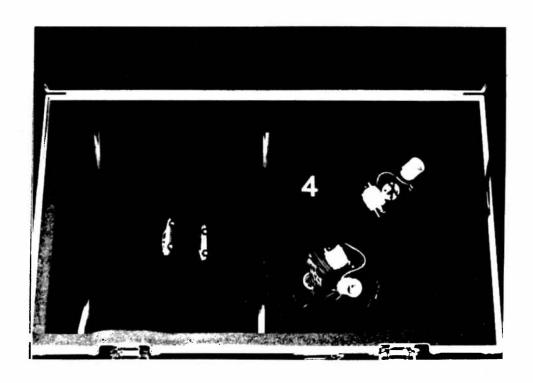




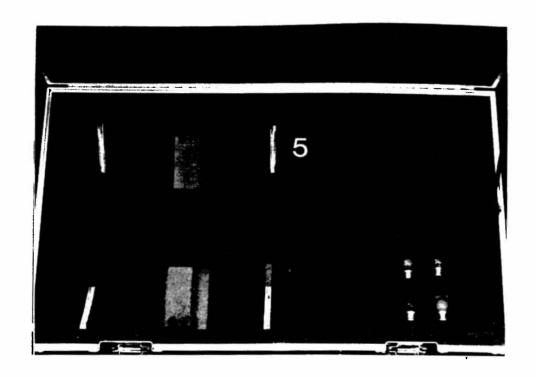


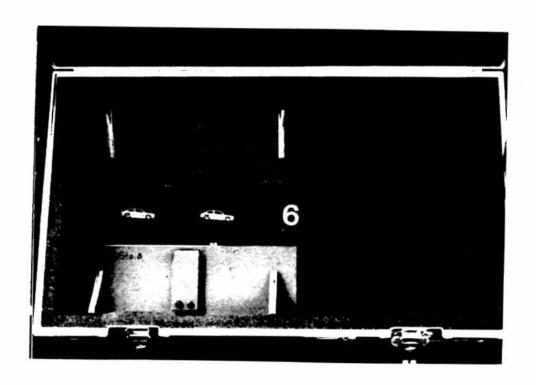




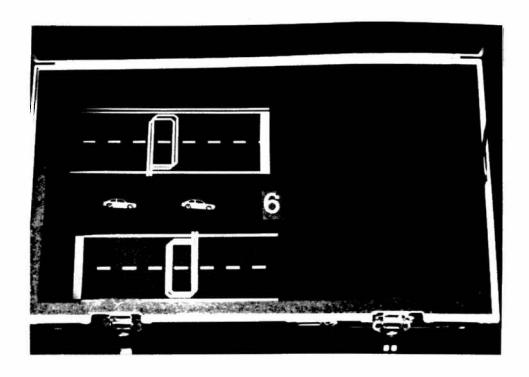


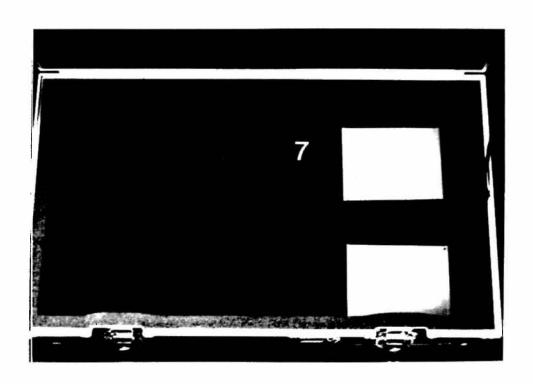
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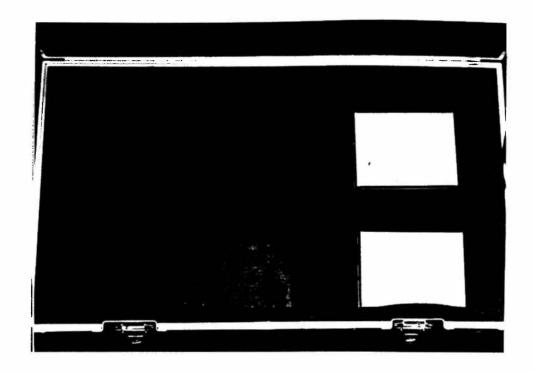




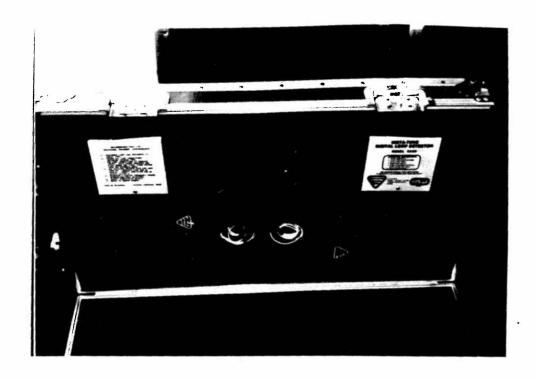
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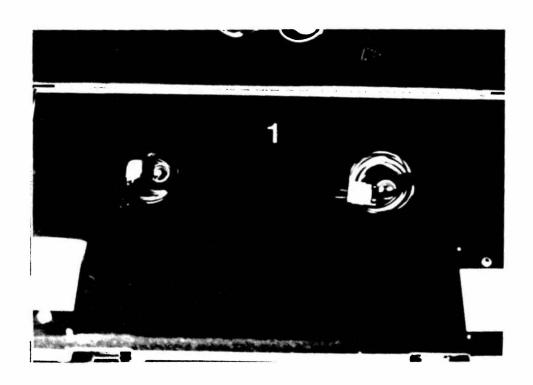


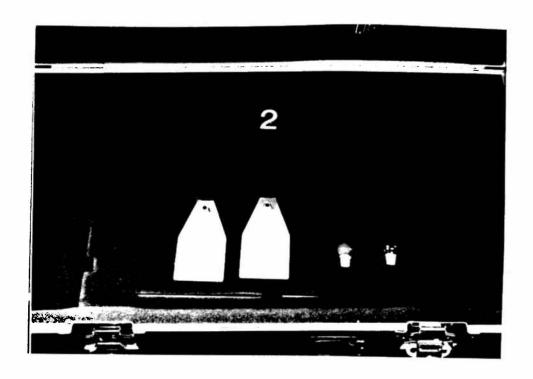


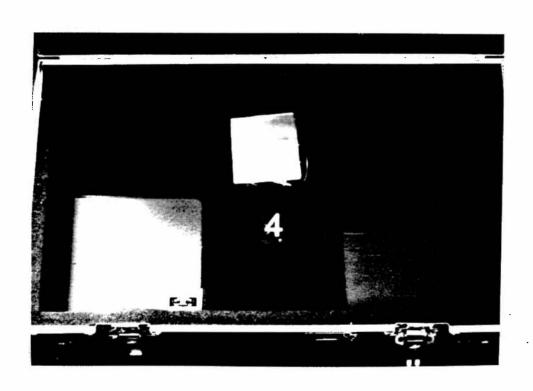


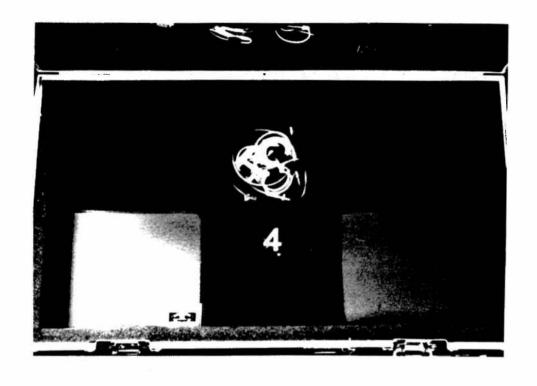
PACKING PROCEDURES FOR TRUNK NO. 6

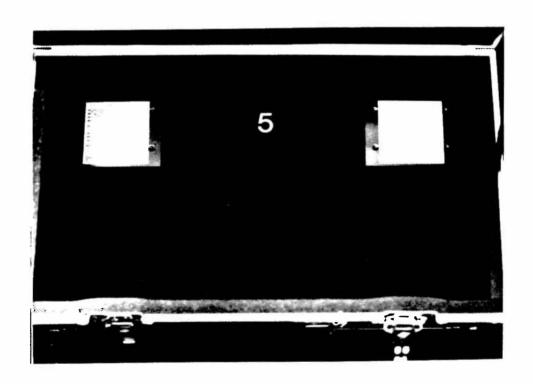


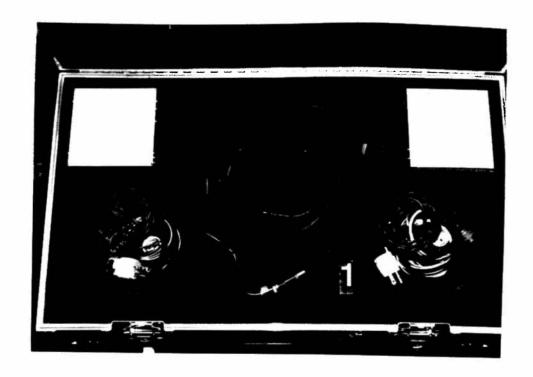


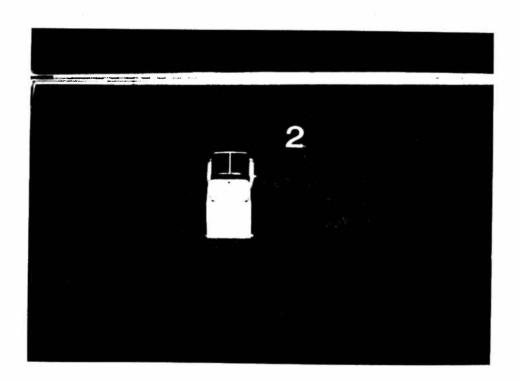


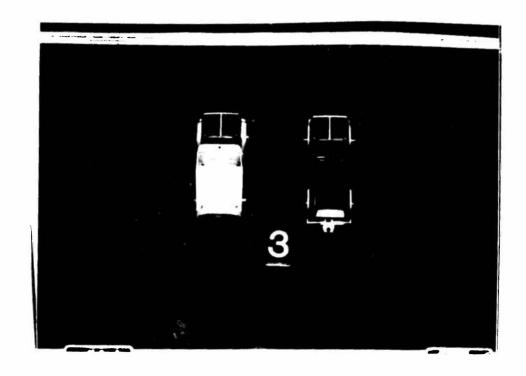


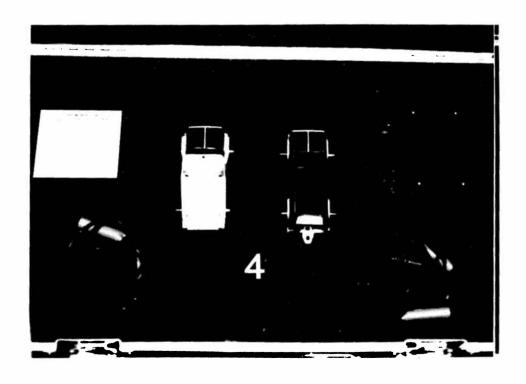


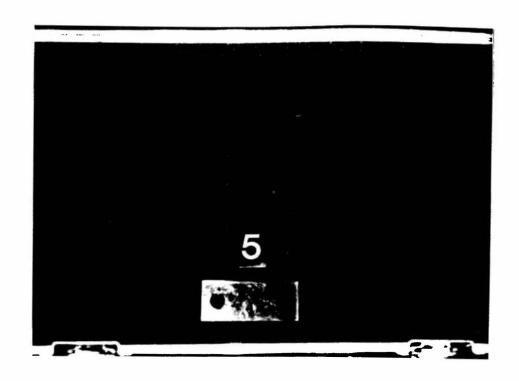


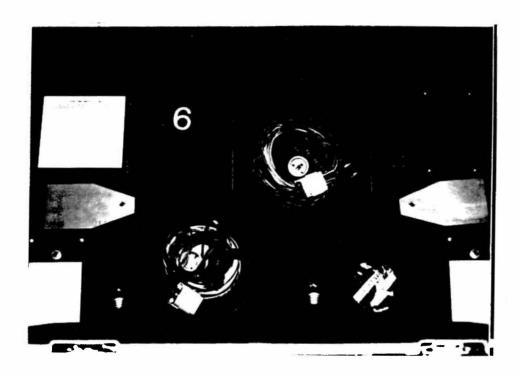






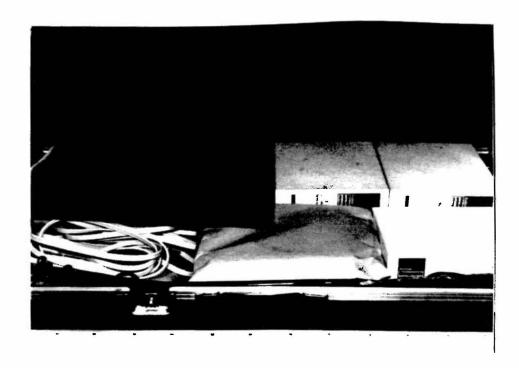




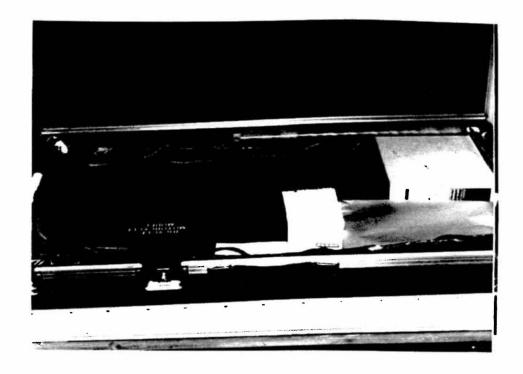




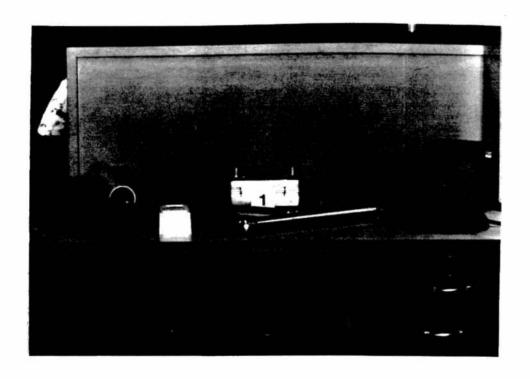




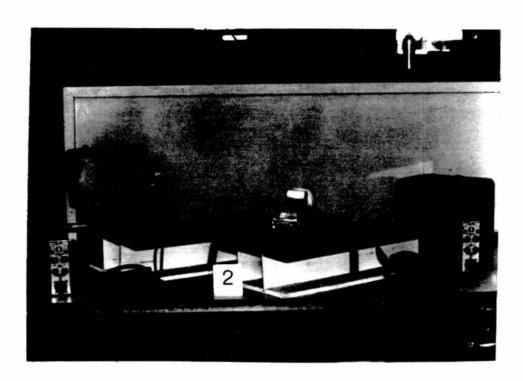




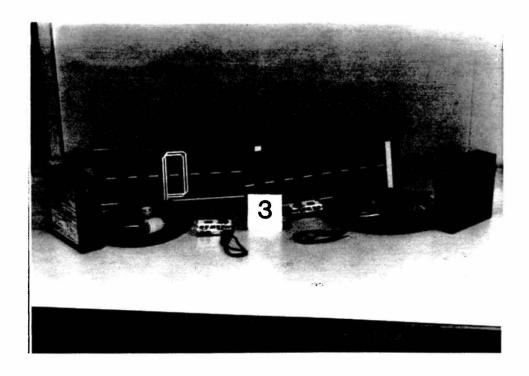
STATION NO. 1 - MAGNETIC DETECTOR



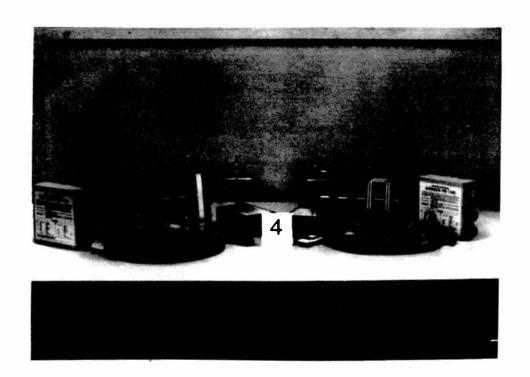
STATION NO. 2 - MAGNETOMETER DETECTOR



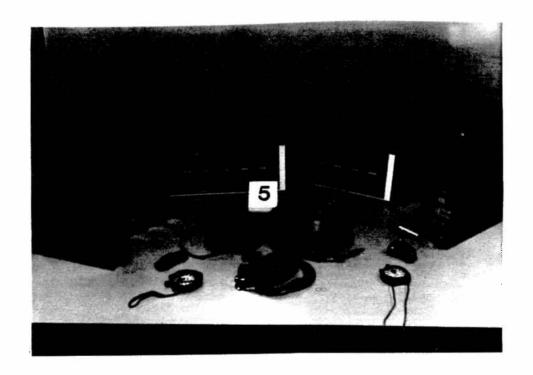
STATION NO. 3 - ANALOG ILD WITH TIMING



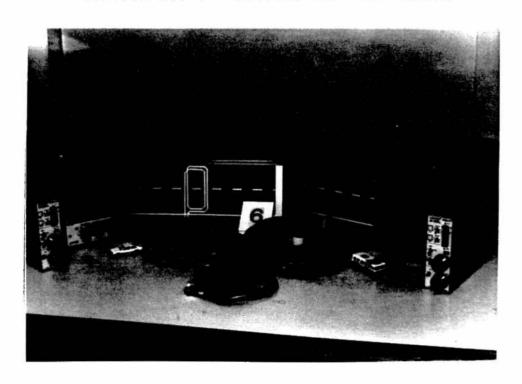
STATION NO. 4 - DIGITAL ILD WITH VARIABLE-L BENCH LOOP



STATION NO. 5 - DIGITAL ILD WITH TIMING



STATION NO. 6 - DIGITAL ILD WITH TIMING



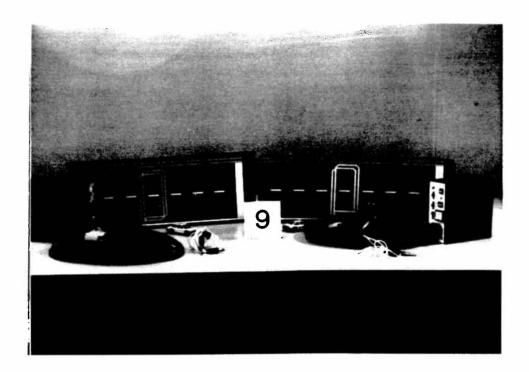
STATION NO. 7 - DIGITAL ILD BUILT TO NEMA SPECIFICATIONS



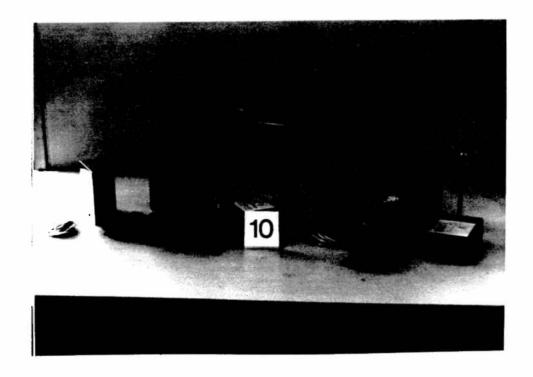
STATION NO. 8 - DIGITAL ILD BUILT TO NEMA SPECIFICATIONS



STATION NO. 9 - DIGITAL ILD WITH INNOVATIVE TIMING



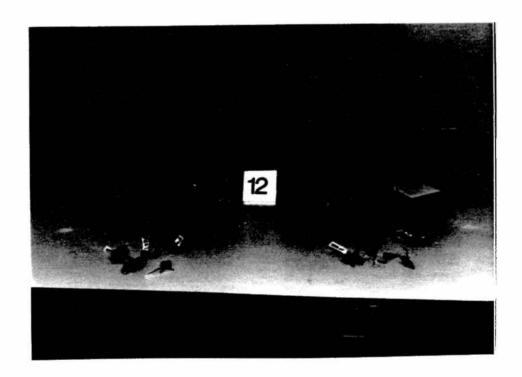
STATION NO. 10 - FREQUENCY-SHIFT DIGITAL ILD WITH VARIABLE-L LOOP



STATION NO. 11 - CRYSTAL-CONTROLLED ILD



STATION NO. 12 - ANALOG ILD WITH VARIABLE-L BENCH TEST LOOP



SESSION 1. INTRODUCTION

REFERENCES: Chapter 1, Traffic Detector Handbook

1.11 TERMINOLOGY OF DETECTORS
(2 MINUTES)

A. Glossary in back of Handbook turn to it.

1.12 NEED FOR DETECTORS
(2 MINUTES)

- A. The basic issues with respect to detectors are concerned with arriving at answers to these questions.
- B. Detectors can be used singly or in multiple installations to measure presence, volume, occupancy, speed and delay at these areas shown:

1.13 EVOLUTION OF DETECTORS (2 MINUTES)

- A. Adler's Horn appears to be first type
- B. Harry Haugh developed the pressure sensitive detector and installed it weeks after Adler installed his in Baltimore.
- C. There are a variety of detector types.

SLIDE 1-18

GLOSSARY OF TERMS

SLIDE 1-19

DETECTORS

- What kind
- What for
- How many
- Where

SLIDE 1-20

APPLICATIONS

- Intersection Control
- Signal Systems
- Freeway Systems

SLIDE 1-21



SLIDE 1-22

DETECTORS

- Pressure Sensitive
- Magnetic
- Photo-electric
- Radar
- Sonic
- Infrared
- Inductive Loop
- Magnetometer

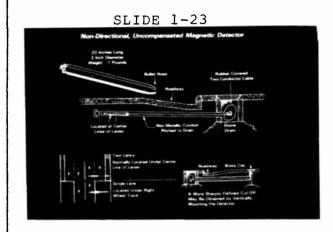
SESSION 1. INTRODUCTION

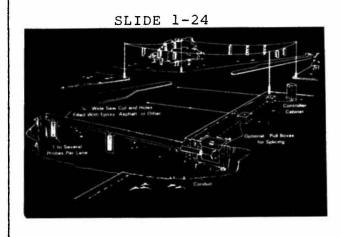
REFERENCES: Chapter 1, Traffic Detector Handbook

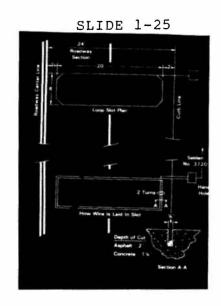
- D. We will concentrate on three types of detectors.
 - Magnetic

Magnetometer

Inductive Loops







SESSION 1. INTRODUCTION

REFERENCES: Chapter 1, Traffic Detector Handbook

1.14 SUMMARY OF DETECTORS (2 MINUTES)

A. Review Table

1.15 MOVIE "LOOP-OCCUPANCY CONTROL"
(30 MINUTES)

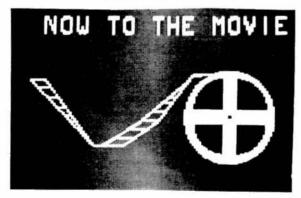
- Applications of long-loop presence detectors and controllers with non-locking detection memory.
- Selection of loop length and controller settings.
- Loop designs for detecting small vehicles.

SLIDE 1-26



GROUP 2 - come for the control of the control control of the contr

SLIDE 1-27



SESSION OVERVIEW

SESSION 2 Tuesday, 10:10 A.M.-11:30 A.M. 2 hr. 50 minutes and 12:30-2:00 P.M.

SESSION TITLE:

DETECTOR THEORY AND HARDWARE

SYNOPSIS:

This is a long session broken by a lunch period. This session provides technical information of practical importance for inductive loop detectors (ILD's), magnetometer detectors and magnetic detectors. For each one we will cover the theory of operation, the characteristics of the sensing unit in the roadway, the wire and sealant, the basics of the electronics and controls, other noteworthy factors in the electronics and a summary of commercially available units. A number of fine points of the ILD type are postponed until later. The session concludes with a comparison of the features of the three types on detectors.

LEARNING OBJECTIVES:

This session builds the foundation needed by the participants in order to work hands-on with the equipment at the Instruction Stations during the Workshop Sessions. The theory presented is intended to promote confidence on the part of the participant that he/she has a grasp of what the detector is doing functionally (if not electronically in any detail). As a result of the session the participant will be able to select the type of detector for typical applications and will be aware of the hardware but not the procedures for the installation. The participant will be oriented to the front-panel controls and ready to try his own hand at it during the Workshop Sessions.

SESSION OUTLINE:

| Schedule | Major Topic | <u>Time in</u> Minutes |
|----------|-------------------------------------|---------------------------|
| 2-1 | Introduction | 5 |
| 2.1 | | |
| | Introduction to the ILD | 5 |
| | Loop-System Theory | 15 |
| | Loop Characteristics | 25 |
| | Wire and Sealant | 20 |
| | Electronics and Controls | 50 |
| | ILD Units Commercially Available | 2 |
| 2.2 | | |
| | Introduction to Magnetometers | 3 |
| 2.2-2 | | 3 7 |
| 2.2-3 | Probe Characteristics | 5 |
| 2.2-4 | Wire and Sealant | 2 |
| 2.2-5 | Electronics and Controls | 7 |
| 2.2-6 | Magnetometer Detectors Commercially | |
| | Available | 2 |
| 2.3 | MAGNETIC DETECTORS | |
| 2.3-1 | Introduction to Magnetic Detectors | 3 |
| | Theory of Operation | 6 |
| 2.3-3 | Probe Characteristics | 6 |
| 2.3-4 | Wire, Electronics and Controls, and | |
| | Units Commercially Available | 2 |
| 2.4 | COMPARISON AMONG ILD, MAGNETOMETER | |
| | AND MAGNETIC DETECTORS | 5 |
| • | Total Time | 2 hr. 50 min. |

REFERENCE: Traffic Detector Handbook, Chapter 2

EQUIPMENT AND MATERIALS: In addition to the chalkboard, slide projector and screen, the instructor will need to use the equipment at a number of stations in order to demonstrate various principles and procedures and hardware items. The guide that begins on the next page calls for station equipment to be demonstrated, or shown, in the following order: Station 6, 13, 14, 15, 14, 10, 3, 8, 5, 8, 14, 12, 14, 7, 7, 2, 1.

REFERENCES: Chapter 2

2.1 INTRODUCTION (5 MINUTES)

- A. Title of Session 2:
 "Detector Theory and
 Hardware
- B. Purpose of Session: To provide technical information of practical importance for inductive loop detectors (ILD's), magnetometer detectors and magnetic detector. For each one we will cover the theory of operation, the characteristics of the sensing unit in the roadway, the wire and sealant, the basics of the electronics and controls, other noteworthy factors in the electronics, and a summary of commercially available units. (p. 21).

ELEMENT 2.1 INDUCTIVE LOOP DETECTORS

2.1-1 INTRODUCTION TO THE ILD (5 MINUTES)

A. The ILD is the most widely used type and is an example of an energy-pattern-change detector. (p. 21)



SLIDE 2-2

INDUCTIVE LOOP DETECTORS

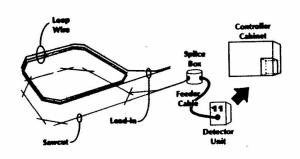
REFERENCES: Chapter 2

B. This figure shows the principal components of an ILD system. (p.21)

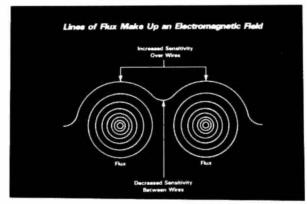
2.1-2 LOOP-SYSTEM THEORY (15 MINUTES)

- A. Basic principles common to all designs (p. 21)
 - Natural frequency of oscillation of tuned circuits.
 - 2. Sources of inductance and capacitance.
 - 3. Flux field and eddy currents.
 - Horizontal line is surface of pavement (slide 2-4)
 - Flux lines seen from above (Slide 2-5)

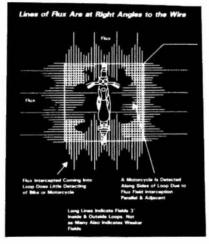
SLIDE 2-3



SLIDE 2-4



SLIDE 2-5



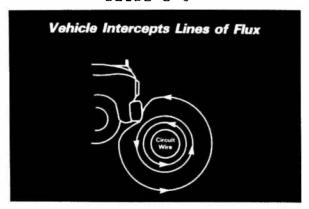
REFERENCES: Chapter 2

 Vehicle entering field causes eddy currents to be induced in body and frame.

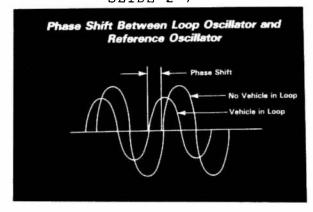
 Inductance goes down, raising the frequency at which the wire wants to resonate.

- 4. Some detectors actually increase their frequency, while others keep it the same and create a phase shift instead. (p. 22)
- B. Resonant Circuitry (p.22)1. Resonant frequency of tuned circuit is a function of L and C
 - A decrease in L increases f

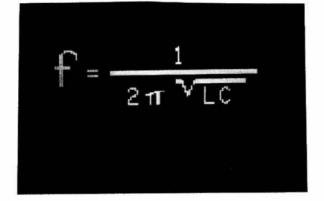
SLIDE 2-6



SLIDE 2-7



SLIDE 2-8



REFERENCES: Chapter 2

- C. Ferromagnetic effect (p.23)
 - 1. Eddy currents in peripheral metal more than offset the effect of the engine mass.
 - Ideally the loop should have a shape approximating vehicle's periphery.
 - 3. Instructor demonstrates the principle of the shorted turn, using equipment from Instruction Station.
- D. Change in inductance (p. 23)
 - Effects of the three variables.
 - 2. Large loops do not detect small vehicles well unless special configurations, discussed later, are used.

2.1-3 LOOP CHARACTERISTICS (25 Minutes)

- A. Introduction (p.23)
 - The field wire will have a certain inductance, dependent on the size and number of turns of a loop or combination of loops, together with the length of lead-in wire.
 - A given detector unit is specified by the manufacturer to be able to operate satisfactorily over a certain range of inductance.
 - 3. NEMA requires 50 to 700 µh

SLIDE 2-9
PRINCIPLE OF THE
SHORTED TURN

SLIDE 2-10

∆L Depends on;

- Height of vehicle above Loop
- Number of Turns
- Size of Loop (area)

SLIDE 2-11

Loop Characteristics

SLIDE 2-12 NEMA REQUIRES 50 to 700 µh REFERENCES: Chapter 2

- B. Determination of inductance
 (p. 23)
 - 1. Table 2 developed from mutual-coupling formula that requires programmable calculator.
 - 2. Shaded boundaries show designs recommended for general use.

Nanohenry is 1/billionth of a henry 1×10^9

Microhenry 1 x 10^6

3M Data on Inductance of Quadrupoles:

1T = 0.5 \(\mu\)h per foot of loop
 (not foot of wire)

2T = 1.5 µh per foot of loop (not foot of wire)

3T = 3.0 µh per foot of loop (not foot of wire)

4T = 5.0 µh per foot of loop (not foot of wire)

- P.P. Quadrupole in Atlanta 6 x 51 computes at 426 and he measured 450 with Safetran.
 - 3. Lead-in adds inductance at rate of 23 uh per 100 feet.
 - o Go over example on p.24 for 6'x6'x3T loop with 200 feet.
 - 4. The material following on p. 24 deals with multiple loops, which will be postponed to Session 13, tomorrow after lunch. Today we will skip pages 25 and 26 and go directly to the top of p. 27, where Sensitivity and Thresholding begins.

SLIDE 2-13
TABLE GIVE

LOOP INDUCTANCES

SLIDE 2-14

$$76 + \frac{200}{100} \times 23 = 76 + 46$$

REFERENCES: Chapter 2

- C. Sensitivity and thresholding
 (p. 27)
 - 1. Sensitivity is defined as the smallest change of inductance at the detector terminals that will cause an actuation. It is the detection threshold.
 - 2. Many states specify a
 sensitivity of
 \(^L/L = 0.02\)*
 - 3. A small motorcycle on a 6'x6' loop with 1000' of lead-in produces a ΔL/L of only about 0.03%. page 27
 - 4. A small motorcycle on a 6'x6' loop wired equally with three other loops, with short lead-in, produces a ΔL/L of only about 0.04%.
 - 5. Users desire some safety margin and therefore specify 0.02% sensitivity.
 - 6. Some units are designed to react to ΔL rather than Δ L/L. These detectors are relatively unaffected by lead-in length or loop size or number of loops in series.
 - 7. NEMA specifies both ΔL , and $\Delta L/L$.

SLIDE 2-15

SENSITIVITY AND THRESHOLDING

SLIDE 2-16

SPECIFIED SENSITIVITY

 $\Delta L/L = 0.02%$

SLIDE 2-17
SMALL MOTORCYCLES AND
LONG LEAD-IN PRODUCE
WEAK SIGNAL

SLIDE 2-18



SLIDE 2-19

ΔL vs ΔL/L

REFERENCES: Chapter 2

8. We now skip to p.29.

2.1-4 WIRE AND SEALANT (20 Minutes)

(Go to Demo. Station with 3 pages of these notes in hand. Have someone else advance the slides.)

- A. Introduction (p. 29)
 - 1. We will discuss the materials used for loop wire and its insulation; loop sealant; lead-in cable; and specialized materials to give added resistance to loop-wire breakage due to pavement instability. Installation procedures are covered in Chapter 4, to be discussed this afternoon.
- B. Loop wire and insulation type (p. 29)
 - Briefly state that Everall, Dorsey and the City of Los Angeles are quoted.
 - 2. Consensus is that loop wire should be number 12 or 14 AWG, stranded. It should be heavily insulated, preferably with cross-linked polyethlene.
 - XHHW is good example
 - Show sample from demonstration station.
- C. Loop Sealant (p. 29)
 - Early types had to be heated (asphalt) or were too hard and brittle (epoxy), or bonded poorly or were expensive.

SLIDE 2-20

WIRE AND SEALANT

SLIDE 2-21

LOOP WIRE AND INSULATING TYPE

SLIDE 2-22



SLIDE 2-23

LOOP SEALANT CHARACTERISTICS

REFERENCES: Chapter 2

- Desirable characteristics on two slides.
- Show samples from Station 13.
- Relative merits of encapsulation on the one hand and shallow sealant and free wires on the other.
- D. Lead-in Cable (p. 30)l. Reasons for twists and shielding
 - 2. Belden 8720 would be improved by nylon armor jacket and a waterblocking fill.
 - 3. Digital units can use smaller wire. Illinois DOT saves two thirds cost.
 - 4. Show samples from Station 13. (Beldon 8720 3M Home-Run)
- E. Heavy-duty loop installation
 - 1. ICC preformed loop in PVC pipe.
 - Sample from Station 15.
 - 2. Utah DOT preformed loopSample from Station 14.

SLIDE 2-24

- HARD ENOUGH
- FLEXIBLE ENOUGH
- CORRECT WEAR PROPERTIES
- ADHERENT
- RAPID CURING

SLIDE 2-25

- EASY TO USE
- USABLE BELOW FREEZING
- MOISTURE-INSENSITIVE
- RESISTANT TO CHEMICALS
- PROPER CONSISTENCY

SLIDE 2-26 COMPLETE ENCAPSULATION OF WIRES

SLIDE 2-27

LEAD-IN CABLE

SLIDE 2-28

HEAVY-DUTY LOOP INSTALLATION

REFERENCES: Chapter 2

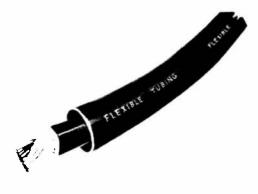
- 3. California DOT's portable disposable loop.
 - Materials seem to be very difficult to find, so do not recommend using this loop.
- 4. Use of vinyl tubing by Illinois DOT.
 - Sample from Station 14.

2.1-5 ELECTRONICS AND CONTROLS (50 MINUTES)

(Go Back up front)

- A. Introduction (p. 33)
 - 1. Review of principles of operation from traffic engineer's viewpoint.
- B. Fixed-frequency designs
 (p. 34)
 - 1. Crystal fixes frequency at about 100 KHz.
 - Tuning a crystal detector applies the needed capacitance across the loop terminals. Manual process.
 - Show ILD unit from Station 11, demonstrate tuning procedures.
 - 3. Long lead-in applies so much capacitance that tuning is impossible.
 - 4. Environmental drift of field wire made tuning fussy. Units would lock out during cooling rains.

SLIDE 2-28A



SLIDE 2-29
ELECTRONICS AND CONTROLS

SLIDE 2-30

CRYSTAL-CONTROLLED LOOP DETECTORS

REFERENCES: Chapter 2

 Drift problem demanded close attention to installation materials, practices.

- C. Analog phase-shift detectors
 (p. 34)
 - 1. In the early 1970's crystal detectors began to be replaced by Sarasota type units. Sarasotas have two oscillators that are variable rather than crystal-controlled.
 - Show ILD unit Sarasota 235T.
 - Analog units are based on varying voltages.
 - Manual tuning process matches oscillator frequency to that of field wire.
 - Demonstrate tuning procedure.
 - 3. Arrival of vehicle produces phase shift.
 - 4. Detector automatically "tracks" drift using analog circuit featuring a "memory capacitor".
 - More details later on how tracking works
- D. Analog frequency-shift detectors. Omit as they are not used.
- E. Digital frequency-shift detectors (p. 35)
 - This section describes units similar to the ICC design.

SLIDE 2-31 ANALOG PHASE-SHIFT LOOP DETECTORS

SLIDE 2-32

DIGITAL FREQUENCY-SHIFT LOOP DETECTORS

REFERENCES: Chapter 2

- Show ILD unit from Station 8
- Demonstrate tuning procedure
- 2. Manufacturer's reference to "digital-ratioed" design means that the unit reacts to changes in \(\Delta L/L. \)
- Digital units use numerical counts rather than varying voltages.
 - Frequency-shift design counts loop frequency cycles, so f is made high to speed up counting.
- 4. Arrival of vehicle produces a change in frequency of oscillation.
 - Demonstrate using ICC tester.
- 5. Detector automatically tracks drift but tracking is postponed for 3 minutes after vehicle arrives, to assure that detection will hold long enough for green to come.
- F. Digital period-shift detectors. (p. 37)
 - 1. This section describes units similar to the Canoga/3M design.
 - Show ILD unit from Station 5.

SLIDE 2-33

DIGITAL PERIOD-SHIFT LOOP DETECTORS

REFERENCES: Chapter 2

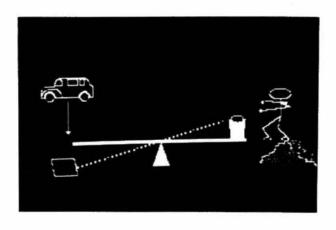
- 2. Fundamental difference between period-shift and frequency-shift designs is that period-shift counts the cycles from a high-speed reference clock, whereas frequency-shift counts the cycles of whatever frequency the loop is operating at.
- 3. Demonstrate automatic tuning procedure.
- 4. Detection circuitry is faster than the frequency shift design, so fast that there is time to "scan" four small loops several times per second. Each loop is energized and analyzed separately, one at a time.
 - We will return to multi-channel operation.
- 5. Like other digital designs, it tracks out environmental drift after a delay to ensure that green has time to come to waiting vehicle.
- G. Environmental Tracking (p. 44)
 - Improperly designed scheme may drop call before green arrives, or could lock calls in or out.

SLIDE 2-34
ENVIRONMENTAL TRACKING

REFERENCES: Chapter 2

- Sarasota-type unit uses a memory capacitor, the function of which can be explained through a seesaw analogy.
 - Explain three rates of shoveling sand.
 - Reason that man cannot stop shoveling upon arrival of a vehicle.
 - Demonstration using Sarasota Bench Test Loop and high paddle moved slowly into loop.
- 3. While analog detectors hold reference information as a charge on a capacitor, digital detectors hold it as a stored digital number.
 - Tracking postponement of 3 to 3.8 minutes assures bringing the green but raises question of adequacy of tracking.
 - Use of cross linked polyethylene insulation and complete encapsulation gives assurance of slow drift.

SLIDE 2-35 FIGURE 33



SLIDE 2-36

TRACKING SCHEMES FOR DIGITAL DETECTORS

REFERENCES: Chapter 2

| Н. | Controls (p. 46) |
|----|----------------------------|
| | This section describes the |
| | adjustment of sensitivity, |
| | presence time, presence or |
| | pulse mode, frequency, |
| | delayed-call timing and |
| | extended-call timing. |

- 1. Sensitivity (p. 46)
 - Should be set as high as possible without causing splashover.
 - Eight levels of sensitivity settings are better than three when it is important to detect the small motorcycle but reject the large vehicle in the adjacent lane.
 - Show Canoga unit from Station 5.
- 2. Presence time (p. 46)
 Normally set to Maximum
- 3. Pulse Mode (p. 46)
 - Actuation lasting only 0.1 second is good for counting purposes.
 - Demonstrate using ICC unit from Station 8.
- 4. Frequency adjustment (p. 47)
 - Explain "crosstalk"
 - Demonstrate at Station 14

SLIDE 2-37

CONTROLS

SLIDE 2-38

SENSITIVITY

SLIDE 2-39

PRESENCE TIME

SLIDE 2-40

PULSE MODE

SLIDE 2-41

FREQUENCY ADJUSTMENT

REFERENCES: Chapter 2

- Frequency switch changes f by about 7%, often solving crosstalk problem
- Demonstrate that changing f at Station 14 defeats crosstalk.
- 5. Detectors with timing (p. 47)
 - Use the Detector Systems unit to demonstrate delayed-call only, extended-call only, and both simultaneously.
 - Demonstrate delay-timer override and explain its use.
- I. Multi-channel digital models
 (p. 43)
 - Conserves cabinet space, reduces cost of power supply, etc.
 - Multi-channel models that scan segmentially from one channel to another avoid the crosstalk problem if no more than four loops are involved.
 - Example of Canoga/3M Model P304
 - Higher sensitivity settings require longer scan times

SLIDE 2-42
DELAYED-CALL TIMING
EXTENDED-CALL TIMING

SLIDE 2-43
MULTI-CHANNEL DIGITAL MODELS

SLIDE 2-44
FOUR-CHANNEL SCANNING ILDS

REFERENCES: Chapter 2

- Example of three 150 uh loops (Bottom of page 44).
- Use frequency switch if there are more than four loops.
- J. Recent advances in digital ILD's (p. 44)
 - Some models have features to aid troubleshooting and reduce maintenance costs.
 - Open Loop Test feature allows technician to determine if an open loop has occurred since the last visit to that intersection.
 - 3. Card-rack models can have four channels of detection on a small PC board that plugs into the controller just as any other module.
 - Show our Canoga/3M model
 - Model 170 uses card-rack models

SLIDE 2-45

RECENT ADVANCES

SLIDE 2-46

OPEN-LOOP TEST

SLIDE 2-47

CARD-RACK MODELS, USED ON MODEL 170 CONTROLLERS

REFERENCES: Chapter 2

- Remote Reset allows a master at a distance to clear calls in an effort to restore normal operation.
 - Example of Canoga/3M card-rack model.
- K. Other factors in ILD electronics (p. 47)
 - Tuning range Some units will tune and operate over a range much greater than NEMA requires.
 - 2. Loss of detection on long loops during saturated flow. Detector units ought to be able to continue outputting for at least an hour.
 - Unit cited in Handbook as having 15 minute maximum has been taken off market.
 - 3. Loss of sensitivity with increasing length of lead-in.
 As we discussed earlier, some models experience little drop-off in sensitivity as lead-in is increased. A "swamping" inductor is used in these designs.
 - Examples of Canoga/3M and Detector Systems units.

SLIDE 2-48

REMOTE RESET

SLIDE 2-49

OTHER FACTORS IN ILD ELECTRONICS

SLIDE 2-50

NEMA REQUIRES TUNING RANGE OF 50 to 700 uh

SLIDE 2-51

LOSS OF DETECTION ON LONG LOOPS
DURING SATURATED FLOW

SLIDE 2-52

LOSS OF SENSITIVITY WITH INCREASING LENGTH OF LEAD-IN

REFERENCES: Chapter 2

- 4. We will now skip the rest of p. 47 and all of p. 48 and 49, as these are fine points to be covered later. Go to p. 50.
- 5. Failsafe operation with loops that are grounded or open. (p. 50)
 - Most modern units have a transformer that allows normal operation if the loop is grounded at a single point. An open loop causes a fail-safe constant-call.
 - Demonstrate using a unit with blue light readily visible to participants, such as the Detector Systems unit.
- 6. Lightning damage
 - NEMA requires that the unit withstand 3000 volts applied across the terminals.

2.1-6 ILD UNITS COMMERCIALLY AVAILABLE (2 MINUTE)

Briefly point out features of Table 3

ELEMENT 2.2 MAGNETOMETER DETECTORS

SLIDE 2-53

FAILSAFE OPERATION WITH LOOPS THAT ARE GROUNDED OR OPEN

SLIDE 2-54

LIGHTNING DAMAGE AND OTHER ELECTRICAL INTERFERENCE

SLIDE 2-55

ILD UNITS COMMERCIALLY AVAILABLE

SLIDE 2-56

MAGNETOMETER DETECTORS

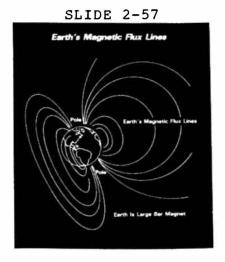
REFERENCES: Chapter 2

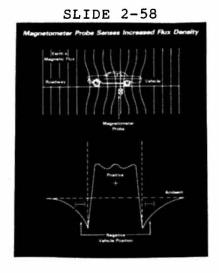
2.2-1 INTRODUCTION TO MAGNETOMETERS (3 MINUTE)

Normally used for small-area detection only, to actuated locking controllers or to count vehicles. Often installed under bridge decks, where slots can't be cut for loops.

2.2-2 THEORY OF OPERATION (7 MINUTES)

- A. Earth's magnetic flux lines (p.50)
 - Location must be far enough from equator to have a certain minimum vertical component of earth's magnetic field.
 - Demonstrate use of field strength meter at Station
 (need .2 oersteds)
- B. Vehicle's magnetic shadow
 (p. 53)
 - 1. The vehicle concentrates the earth's flux lines into a "magnetic shadow".
 - Magnetometer senses the increased flux below the vehicle.





REFERENCES: Chapter 2

2.2-3 PROBE CHARACTERISTICS (5 MINUTES)

A. Description (p. 54)

- 1. Show one of the probes at Station 2. They are installed in a drilled hole in the pavement about one foot deep. this is beneath the paving, in soil, then measures must be taken to see that the probe cannot tilt at all, as that will produce faulty operation. A length of PVC pipe can be used to hold the probe vertical. Figure 39 shows that the core and windings resemble a transformer. There is no radiated field.
- B. The probe in the overall system (p. 54)
 - 1. The system has high inherent sensitivity and signal-to-noise ratio. In effect the probe is "looking upward" with what amounts to a narrow "cone of vision". Therefore it is definitely a small-area detector.
- C. Sensitivity and thresholding
 (p. 55).
 - 1. The small-aperture view and the passive design, with no radiated field, means that a portion of the vehicle must pass over the probe. There is a clean cut-off from one vehicle to another, so this device is good for counting.

SLIDE 2-59

MAGNETOMETER PROBE CHARACTERISTICS

SLIDE 2-60

MAGNETOMETER SENSITIVITY AND THRESHOLDING

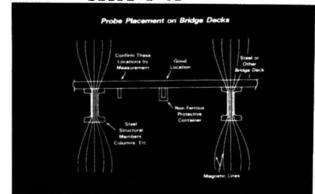
REFERENCES: Chapter 2

- 2. At the same time, a single probe buried a foot below the pavement surface does not locate the perimeter of the vehicle well enough. Two probes are needed for determining occupancy and speed. Most users prefer the ILD for this application.
- Magnetometers can detect bicycles, hold infinite presence, cannot crosstalk, and require no motion.
- 4. With several probes in series the sensitivity is divided among them. The unit will detect with a vehicle over one probe out of five.
- D. Influence of reinforcing steel (p. 55)
 - Nearby horizontal steel is O.K., but probes must be kept away from vertical steel.
 - 2. More in chapters 3 and 4.

SLIDE 2-61

INFLUENCE OF REINFORCING STEEL

SLIDE 2-62



REFERENCES: Chapter 2

2.2-4 WIRE AND SEALANT (2 MINUTE)

- A. Probe-interconnect cable and lead-in cable are described. Lead-in need not be shielded.
- B. Sealant is same as for ILD, and wire and splices must be absolutely waterproof, same as for ILD.
 - Magnetometer splice kit at demonstration station.

2.2-5 ELECTRONICS AND CONTROLS (7 MINUTES)

- A. Introduction (p. 56)
 - The electronics unit consists of two completely independent channels with from 1 to 12 series-connected probes on each channel.
 - Show unit at Station 2
- B. Tuning procedure (p. 56)
 - Remove portable metal objects within 20 feet of probe (in field, not lab)
 - Turn calibration knob until flashing light indicates that ambient (existing) field has been compensated for.
 - Demonstrate this at Station 2.

SLIDE 2-63

MAGNETOMETER WIRE AND SEALANT

SLIDE 2-64

MAGNETOMETER ELECTRONICS AND CONTROLS

SLIDE 2-65

MAGNETOMETER TUNING PROCEDURE

REFERENCES: Chapter 2

C. Controls (p. 56)

- 1. This means Operating
 Modes. There are four to
 select on front panel:
 (demonstrate at
 Station 2):
 - Presence Gives unlimited hold time.
 - Extended presence Up to 5 seconds of "stretch" or "carryover output" or "extended call."
 - Pulse Only 40 ms long. No possibility of multiple pulses from a vehicle that remains over the probe.
 - Inhibited pulse An adjustable Pulse Mode Reset (see text above on ILD units, p. 47, which we will cover tomorrow under Fine Points title). Eliminates multiple pulses from tanker trucks, trailers.
 - Delayed-call timing is not available.

2.2-6 MAGNETOMETER DETECTORS COMMERCIALLY AVAILABLE (2 MINUTE)

The only available units are the 3M/Canoga shelf-mounted and rack-mounted models at Station 2.

SLIDE 2-66

MAGNETOMETER'S FOUR OPERATING MODES:

- PRESENCE
- EXTENDED PRESENCE
- PULSE
- INHIBITED PULSE

SLIDE 2-67

MAGNETOMETERS COMMERCIALLY AVAILABLE

REFERENCES: Chapter 2

Show card-rack model

ELEMENT 2.3 MAGNETIC DETECTORS

2.3-1 INTRODUCTION TO MAGNETIC DETECTORS (3 MINUTE)

These are simple, inexpensive and rugged but useful only for small-area detection for signal controllers operated in locking mode. Popular in northern states with harsh winters and crumbling pavements. (p.56)

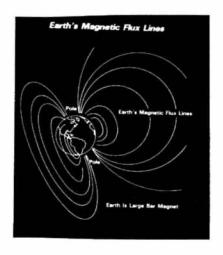
2.3-2 THEORY OF OPERATION (6 MINUTES)

Inert coils in a housing under the pavement normally have no current flowing through (in absence of vehicles), and no radiated field.
Totally inert. Motion of arriving vehicle disturbs earth's flux, induces tiny voltage in coils. Detector electronics amplify it enormously to operate the output relay.

- Demonstrate using toy truck at Station 1.
- Demonstrate the cutting of flux lines by waving probe through the air, producing actuations.

SLIDE 2-68
MAGNETIC DETECTORS

SLIDE 2-69



REFERENCES: Chapter 2

2.3-3 PROBE CHARACTERISTICS (6 MINUTES)

Current models do not need to be compensated for nearby trolley rails, and today streets are wide enough so that they seldom need to have directional capability. So current models are non-directional, uncompensated.

- A. Non-directional, uncompensated probe (57)
 - 1. Surface unit appears to be a small ceramic block mounted inside a rugged, load-bearing, cast aluminum box. Ceramic block has coils inside. (Show at Station 1). Box is installed flush with road surface.
 - 2. Subsurface unit resembled a brass projectile in early days, now is aluminum tube resembling a probe, with coils inside (show at Station 1). Installed either by inserting into a hole bored under the pavement or by laying in open trench excavated in road.
 - Show length of PVC pipe at Station 1

We will omit mention of the directional, compensated models, as they are rare.

SLIDE 2-70

PROBE CHARACTERISTICS OF MAGNETIC
DETECTORS

SLIDE 2-71

MAGNETIC DETECTORS ARE
NON-DIRECTIONAL, UNCOMPENSATED,
AND EITHER SURFACE-TYPE OR
SUBSURFACE-TYPE

REFERENCES: Chapter 2

B. Zone of influence (p. 58)

- 1. The output continues for as long as the vehicle is in motion at the detector, but the zone of influence (as well as the pick-up and drop-out characteristics) are not well enough defined and stabilized to permit measurements of speed and occupancy.
- No way to create a large area of detection permitting non-locking controller operation (as with long loops).
- 3. It is simply a passage detector for rudimentary actuated control.
- 2.3-4 WIRE, ELECTRONICS AND CONTROLS, AND UNITS COMMERCIALLY AVAILABLE (2 MINUTES)

Show participants the heavily insulated, waterproof wire on the subsurface (probe) unit at Station 1.

See Table 4 for models commercially available

ELEMENT 2.4 COMPARISON AMONG ILD, MAGNETOMETER AND MAGNETIC DETECTORS (5 MINUTES)

Table 5 compares the three types of detectors on many characteristics. (3 minutes)

SLIDE 2-72

ZONE OF INFLUENCE OF MAGNETIC DETECTORS

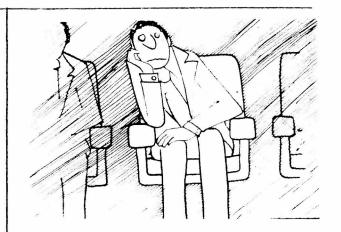
SLIDE 2-73

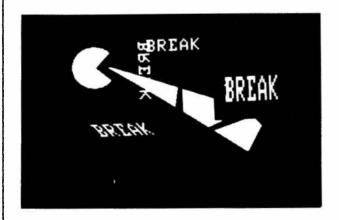
MAGNETIC DETECTORS COMMERCIALLY AVAILABLE

SLIDE 2-74

COMPARISON OF DETECTORS

REFERENCES: Chapter 2





SESSION 3
ORIENTATION TO
WORKSHOP SESSIONS

SESSION OVERVIEW

SESSION 3 Tuesday, 2:15-3:15 P.M.

60 minutes

SESSION TITLE:

ORIENTATION TO WORKSHOP SESSIONS

SYNOPSIS:

The participants will have only a moderate amount of assistance and supervision during the Workshop Sessions; so it is essential that they be brought up to the point where they understand the exercises well enough to work on their own most of the time. Session 2 was intended to build the foundation for the Workshop Sessions, and now the present session should complete the orientation. Fifteen Stations cannot be covered in depth in 60 minutes, so the guide that follows this overview suggests selected exercises for emphasis.

LEARNING OBJECTIVES:

As a result of this session each participant is supposed to be in a position to perform the exercises at the Instruction Stations with only moderate supervision and assistance.

SESSION OUTLINE:

| | | Time in |
|-----------------|--|----------------|
| <u>Schedule</u> | Major Topic | <u>Minutes</u> |
| 3.0 | Orientation | 5 |
| 3.1 | Magnetic Detector | 1 |
| 3.2 | Magnetometer Detector | 2 |
| | | |
| 3.3 | Analog ILD with Timing | 3 |
| 3.4 | Digital ILD with Variable Bench-Test Loop | 3 |
| 3.5 | Digital ILD with Timing | 4 |
| 3.6 | Digital ILD Built to NEMA Specifications | 4 |
| 3.7 | Digital ILD with Innovative Timing | 3 |
| 3.8 | Frequency-Shift Digital ILD with | |
| | Variable-L Loop | 4 |
| 3.9 | Digital ILD | 1 |
| 3.10 | Crystal-Contolled ILD | 4 |
| 3.11 | Analog ILD with Variable-L Bench-Test Loop | 6 |
| 3.12 | Micro-loop and Analog ILD | 1 |
| 3.13 | Installation Materials | 1 |
| 3.14 | Exercises Using Preformed Loops | 4 |
| 3.15 | Loop-Test Equipment | 4 |
| 3.16 | Assignment of Participants to Stations | 10 |
| | Total Time | 60 minutes |

REFERENCE: Student Notebook, Section giving Instructions for Workshop Sessions

EQUIPMENT AND MATERIALS: The instructor will use the equipment at the Instruction Stations. There are no slides for this session.

SESSION 3 ORIENTATION TO WORKSHOP SESSIONS

REFERENCE: Student Notebook, Section giving Instructions for Workshop Sessions. There are no slides for this session.

3.0 ORIENTATION TO WORKSHOP SESSIONS (5 MINUTES)

Cover the first 2-1/2 pages of the Instructions. Participants will work in teams of two at each Station for 30 minutes. The exercises at each Station consist of a number of objectives. The exercises are written so that the participant can go from Station to Station in any order.

Please leave the factory manuals and other literature at the Stations.

Delicate tests with ILD's require that the unit be "warmed up" for 30 minutes, so leave power on the equipment except when the exercises call for brief power interruptions.

The assignment of partners to instruction stations will be done at the end of this hour.

3.1 STATION 1 -- MAGNETIC DETECTOR

This Station was thoroughly covered in Session 2, so just pass a toy truck over a probe briefly and explain that this Station is the simplest.

3.2 STATION 2 -- MAGNETOMETER DETECTOR

Just as was demonstrated in Session 2, the participants will tune the shelf-mounted model and demonstrate the four operating modes. Instructor need only show how to do the Fourth Objective, showing that slight tilting of the probe in the drillhole can affect performance.

3.3 STATION 3 -- ANALOG ILD WITH TIMING

Remind the participants of the way to inhibit the delay feature by applying 115 V to Pin J. Also, demonstrate power interruption, broken wire and a short to ground at one point.

3.4 STATION 4 -- DIGITAL ILD WITH VARIABLE-L BENCH TEST LOOP

Point out the unusual procedure for setting sensitivity with these units. Demonstrate the Fifth Objective, "presence holdtime for small motorcycles" but don't take the time to wait for the call to drop.

3.5 STATION 5 -- DIGITAL ILD WITH TIMING

Remind participants that the Sensitivity - thumbwheel numbers have a "hat" on them for "pulse mode". Emphasize that in the Fourth and Fifth Objectives they are to unplug the power cord before opening the case to set the timing. Remind them that 115 V is enough to kill if you are well grounded.

3.6 STATION 6 -- DIGITAL ILD WITH TIMING

Remind participants that the equipment at Station 5 and 6 is the same.

Demonstrate the Fifth Objective, which is the loss of sensitivity due to steel reinforcing mesh. (We will talk about that tomorrow under Fine Points.)

Regarding the Sixth Objective, regarding crosstalk, the participants will be transferring their ILD's to Station 14. Almost all of the ILD's in this course are interchangeable as they use the standard 10-pin MS connector.

3.7 STATION 7 -- DIGITAL ILD BUILT TO NEMA SPECIFICATIONS

Point out that these units have NEMA connectors and therefore are not interchangeable with the old-style MS connectors that are on every other ILD in the room. Then demonstate the Fifth objective regarding power interruption. Point out that NEMA requires that no manual retuning or resetting shall be required and that the unit shall automatically achieve normal operation and at least 90 percent of the selected sensitivity within 3 minutes after restoration of power.

3.8 STATION 8 -- DIGITAL ILD BUILT TO NEMA SPECIFICATIONS

The equipment at this station is the same as for Station 7. Then demonstrate the Third Objective, which is the 3M test for capability to track environmental drift. Emphasize that it is a delicate test, and we will provide assistance if needed.

3.9 STATION 9 -- DIGITAL ILD WITH INNOVATIVE TIMING

This unit, like the new Sarasota digital models at Station 4, can act as both delayed-call and extended-call simultaneously. Go over the Fifth Objective and mention that we will cover the EC-DC application when we get to Chapter 3.

3.10 Station 10 -- FREQUENCY-SHIFT DIGITAL ILD WITH VARIABLE-L LOOP

Without taking the time for hands-on demonstration, just explain that in the Sixth Objective the Digital Loop Tester is not driving the loop. The loop is driven by the ICC detector unit. So the Tester is set to EXT, meaning that the loop is driven by some source external to the tester. So the tester is just watching what the regular ILD does with its loop. In the Seventh Objective, on the other hand, the Tester is watching the Bench Test Loop. The Tester will measure the strength of the signals produced when the paddle goes over the loop. For this purpose the Tester wants to take over the driving of the loop, so you switch it to INT for internal excitation.

3.11 STATION 11 -- CRYSTAL-CONTROLLED ILD

Explain the Sixth Objective, which is to demonstrate the capacitance problem in tuning to long lead-in. Demonstrate where to connect the capacitor across the loop terminals, using the banana jacks on the front of the Sensitivity Tester.

3.12 STATION 12 -- ANALOG ILD WITH VARIABLE-L BENCH TEST LOOP

Demonstrate the Third Objective by removing the fuse and noting that this locks in a call. The output relay is designed to be normally energized, as shown on the diagrams accompanying that exercise.

Explain the Fourth Objective, in which the participant adds both inductors and capacitors to simulate long lead-in. Go over the five-step instructions for installing the components.

3.13 STATION 13 -- MICROLOOPS AND ANALOG ILD

Just announce the title of the station and go on the the next.

3.14 STATION 14 -- HEAVY-DUTY LOOPS

Show that the Minimum Vehicle Stimulator is to be laid flat in the center of the loop in order to simulate a small Honda. The MVS can be held on edge to suggest a bicycle.

3.15 STATION 15 -- LOOP-TEST EQUIPMENT

One of the tests with the Decatur Loop Analyzer is to determine the resistance to ground. Show the participants the green wire at the station and show that it is attached to the powercompany ground at the receptacle.

3.16 DISPLAY STATION -- INSTALLATION MATERIAL

This station presents some installation material. The participants are encouraged to examine these materials when they have extra time.

3.17 ASSIGNMENT OF PARTICIPANTS TO STATIONS

Ask the participants to call out the names of themselves and their partners. Write the teams on the chalkboard and assign them letters and characters as explained in the materials. For example, the team of Smith and Jones are assigned the letters A and B, and they are seen on the chart to work at Station 1 during Workshop Session 1. The last team is Burdell and McDonald, assigned ? and %, and they will start at Station 15.

SESSION OVERVIEW

SESSION 5 Wednesday, 8:00-9:00 A.M.

60 Minutes

m 2 --- 2 --

SESSTION TITLE:

LOOP DETECTOR INSTALLATION

SESSION 3: LOOP DETECTOR INSTALLATION

SYNOPSIS:

This session includes a discussion of planning, materials, equipment and the details of loop installation. The discussion includes loop layout, sawing slots, crossing curbs and joints, wire installation, conduit and splice box placement, loop testing, slot sealing, wire splicing, lightning protection and final testing.

OBJECTIVES:

To understand the planning process that should precede the installation and the basic details of loop installation and to understand some basic techniques for improving the quality of an installation. To understand that a sufficient amount of time should be provided for installation so that the installation will remain in working order for years.

SESSION OUTLINE:

| | | Time in |
|----------|------------------------------------|----------------------|
| Schedule | Major Topic | Minutes |
| 5.1 | Introduction | 2 |
| 5.2 | Preliminary Planning | 1 |
| 5.2.1 | Scaled Drawing | 1 |
| 5.2.2 | Field Visits | 1 |
| 5.2.3 | Equipment | 15 |
| 5.2.4 | Materials | 10 |
| 5.3 | Installation Procedures | 1 |
| 5.3.1 | Loop Layout and Sawing Slot | 5 |
| 5.3.2 | Crossing Curbs and Pavement Joints | 4 |
| 5.3.3 | Wire Installation | 4 |
| 5.3.4 | Conduits and Splice Boxes | 3 |
| 5.3.5 | Loop Testing | 2 |
| 5.3.6 | Sealing the Loop | 4 |
| 5.3.7 | Wire Splicing | 5 |
| 5.3.8 | Lead-in Cable Installation | 1 |
| 5.3.9 | Final Testing | 1 |
| | Total Time | $\overline{60}$ Min. |

REFERENCE:

Traffic Detector Handbook, Chapter 4, pp. 103-125.

EQUIPMENT AND MATERIALS: In addition to the chalkboard, slide projector and screen, the instructor will need to use the materials at Stations, 14, and 15 and Display Station.

REFERENCES: Chapter 4, Traffic Detector Handbook

5.1 INTRODUCTION (2 MINUTES)

- A. Title of this session is Loop Detector Installation Procedures and Materials. (page 109)
 - Many techniques used throughout the country.
 - o The most important part of the installation process is to insure that the system will work in the same manner as specified by the designer and that the system will remain in working order for an extended period of time.
 - o The installation should be deliberate and periodic inspections should be conducted throughout the installation process.
- 5.2 PRELIMINARY PLANNING (1 MINUTE)
 - A. The installation process should begin with a well structured, logical plan.
 - B. The planning should include:

SLIDE 5-1

SESSION TITLE



SLIDE 5-2

INSTALLATION SHOULD BE

- o DELIBERATE
- o INSPECTED THROUGHOUT THE PROCESS

SLIDE 5-3

PRELIMINARY PLANNING

SLIDE 5-4

- o DRAWING
- o FIELD VISITS
- o EQUIPMENT REQUIREMENTS
- o MATERIAL REQUIREMENTS

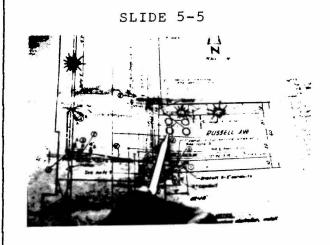
REFERENCES: Chapter 4, Traffic Detector Handbook

5.2.1 SCALED DRAWINGS (1 MINUTE)

- A. Geometry
- B. Sensor Locations
- C. Conduit Runs
- D. Manholes
- E. Power Source
- F. Pavement Materials
- G. Material Quantities

5.2.2 FIELD VISITS (1 MINUTE

- A. Field visits should be made before and after drawing complete.
- B. During the visits the following should be determined:
 - Exact location of sensors,
 - Exact size of area coverage,
 - 3. Location of conflicting utilities like manholes, electrical lines, gas lines, etc.,
 - 4. Location of electrical tie-ins,
 - Location of controller cabinet,
 - Location of water source for cooling power saw,
 - 7. The strategy for burying feeder cables,
 - Types of equipment necessary for installation strategy,

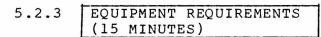


SLIDE 5-6



REFERENCES: Chapter 4, Traffic Detector Handbook

- 9. Time of day best suited for installation,
- Method of traffic routing and control,
- Position and quantity of barricades,
- 12. Determine necessary permits and licenses required for installation.



- A. Power Saw equipped with 1/4 to 3/8 inch blade
 - water valve
 - depth gage
 - horizontal guide

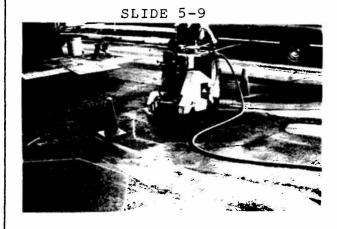
Show blade from Display Station

B. Water Supply-sufficient to keep blade cool. Abrasive blade does not necessarily require water.



SLIDE 5-8

EQUIPMENT REQUIRED FOR LOOP INSTALLATION



SLIDE 5-10



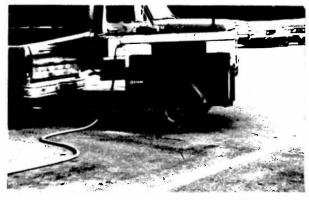
REFERENCES: Chapter 4, Traffic Detector Handbook

C. Air Compressor-to operate jack hammer and air hose.

D. Jackhammer for boring holes through concrete curbs.

E. A small chisel and hammer

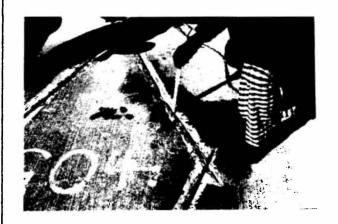
SLIDE 5-11



SLIDE 5-12



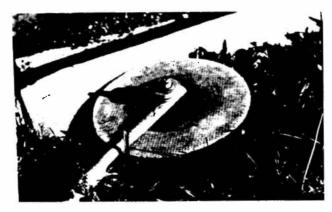
SLIDE 5-13



REFERENCES: Chapter 4, Traffic Detector Handbook

F. A blunt tool-set wire in slot.

SLIDE 5-14

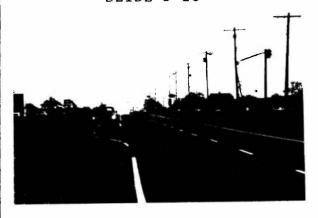


G. A twister-used to twist wire.

SLIDE 5-15



SLIDE 5-16



H. Barricades, signs & cones for traffic control.

REFERENCES: Chapter 4, Traffic Detector Handbook

I. Template or straight edge to outline loop boundary on pavement.

J. Small trenching tool for burying cable in dirt.

K. Equipment for rodding cable in conduit.

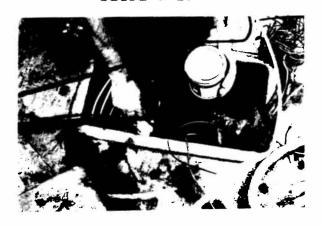
SLIDE 5-17



SLIDE 5-18



SLIDE 5-19



REFERENCES: Chapter 4, Traffic Detector Handbook

L. Equipment for making sodder connections.

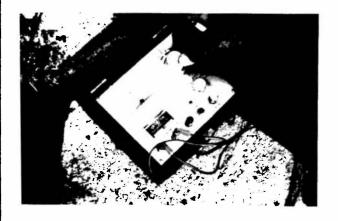
M. Meters for analyzing loops (show meters from Station 15)



SLIDE 5-21



SLIDE 5-22



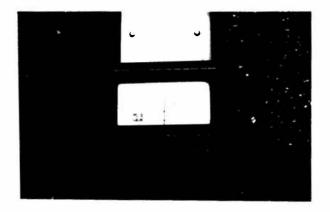
REFERENCES: Chapter 4, Traffic Detector Handbook

M. Meters for analyzing loops (show meters from Station 15) (CONTINUED)

SLIDE 5-23



SLIDE 5-24



SLIDE 5-25



REFERENCES: Chapter 4, Traffic Detector Handbook

5.2.4 MATERIAL REQUIREMENTS (10 MINUTES

- A. Detector Wire
- B. Lead-in Cable

C. Splice Box

D. Sealant

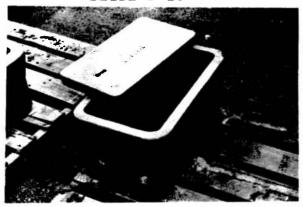
SLIDE 5-26

MATERIALS REQUIRED

SLIDE 5-27



SLIDE 5-28



SLIDE 5-29



REFERENCES: Chapter 4, Traffic Detector Handbook

- E. Splice kits
 - Illinois DOT

• 3 M

- Michigan DOT
- F. Conduit
- G. Surge Arrester
- H. Solder
- I. Spray paint
- J. Wire lubricant
- K. Concrete for setting splice box.

SLIDE 5-30



SLIDE 5-31



SLIDE 5-32



REFERENCES: Chapter 4, Traffic Detector Handbook

5.3 INSTALLATION PROCEDURES (1 MINUTE)

- A. Title of this session is Loop Detector Installation Procedures,
- B. Three major reasons for loop failure.
 - 1. Pavement failure
 - 2. Sealant failure
 - 3. Floating wires
- C. These procedures should help to alleviate these problems.

5.3.1 LOOP LAYOUT AND SAWING SLOTS (5 MINUTES)

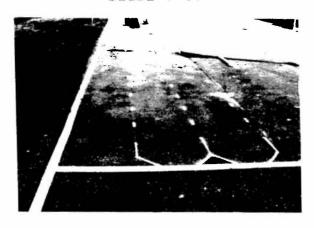
A. Mark on pavement

SLIDE 5-33

INSTALLATION PROCEDURES

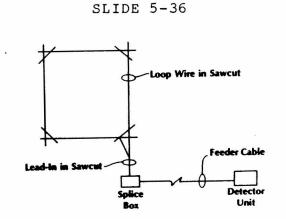
SLIDE 5-34
PAVEMENT FAILURE
SEALANT FAILURE
FLOATING WIRES

SLIDE 5-35

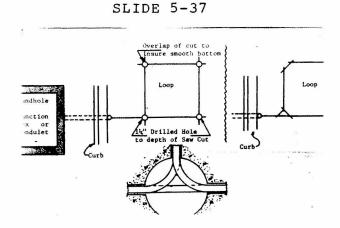


REFERENCES: Chapter 4, Traffic Detector Handbook

B. Chamfer cut - explain disadvantage.



C. Drill corner -



Illinois uses this process. Hole should be no less than 1-1/4 inches.

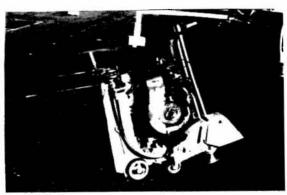


REFERENCES: Chapter 4, Traffic Detector Handbook

- D. A self-propelled, water cooled power saw with diamond blade used to saw slots.
 - An alternative is an abrasive blade with dry process.
 - Diamond blades costs \$600.00 per blade.

- Abrasive blade \$28/blade when bought 20 at a time, life is about 600 feet.
- Can use wet or dry process with abrasive blade - dry is faster and doesn't require extensive clean-ups.
- New York DOT has begun cutting 3/8" wide slots and found that they have numerous breakdowns of their 6 horsepower saw. Therefore they now use an 18 horsepower saw.
- 3/8" wide slot is necessary for wire with plastic tube.
- Slot depth is 1-1/2" to 2".

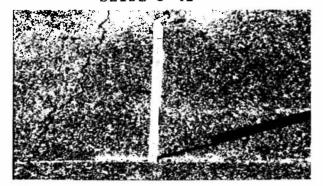
SLIDE 5-39



SLIDE 5-40



SLIDE 5-41



REFERENCES: Chapter 4, Traffic Detector Handbook

E. Clean slots out with compressed air, chisel and hammer.

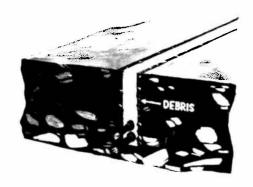
Talk about Nelson Nozzle refer to diagram to be handed out and NYDOT booklet on Installation of Vehicle Detector Loops also to be handed out.

5.3.2 CROSSING CURBS AND PAVE-MENT JOINTS (4 MINUTES)

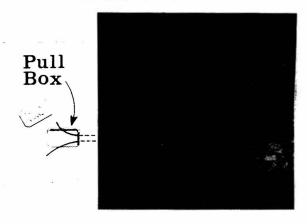
Two problems

- Crossing from road to splice box.
- Wire crosses pavement joint.
- A. Jackhammer used to make hole.

SLIDE 5-42



SLIDE 5-43



SLIDE 5-44



REFERENCES: Chapter 4, Traffic Detector Handbook

B. Conduit used from road surface to splice box.

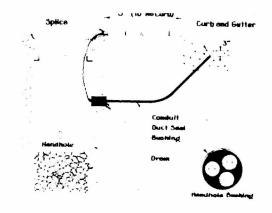
C. Don't do this method for crossing curbs. (explain slide)

D. This method isn't good either.

SLIDE 5-45



SLIDE 5-46



SLIDE 5-47



REFERENCES: Chapter 4, Traffic Detector Handbook

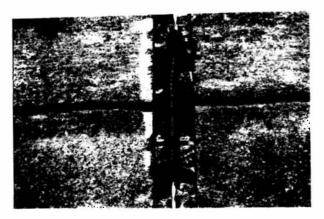
Crossing Pavement Joints

- Because pavement moves at joints it can break wire.
- Reinforcing at joint.

3-inch hole at joint.

 This allows 6 inches of extra wire.

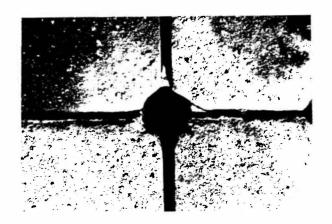
SLIDE 5-48



SLIDE 5-49



SLIDE 5-50



REFERENCES: Chapter 4, Traffic Detector Handbook

5.3.3 WIRE INSTALLATION (4 MINUTES)

- A. Clean out slot
- B. Put sealant in bottom of slot.

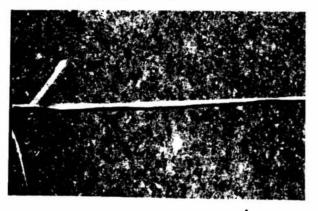
C. About 1/4 to 1/2 inch is adequate.

D. Lay wire in slot; put some tension on wire so that it lays down smooth.

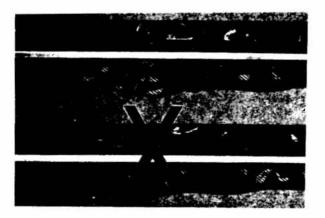
SLIDE 5-51



SLIDE 5-52



SLIDE 5-53



REFERENCES: Chapter 4, Traffic Detector Handbook

E. Wire should come off the spool tangentially to prevent coiling.

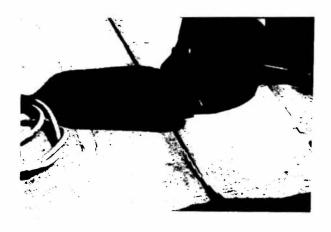
- F. Use blunt instrument to install wires - push into sealant.
- G. Twist lead-in wires 5 turns per foot.

- 5.3.4 CONDUIT AND SPLICE BOX (3 MINUTES)
- A. Load bearing non load bearing.

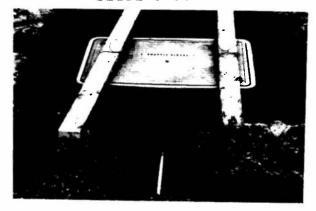
SLIDE 5-54



SLIDE 5-55



SLIDE 5-56



REFERENCES: Chapter 4, Traffic Detector Handbook

- B. Conduit connections.
- C. Provide drainage in bottom.

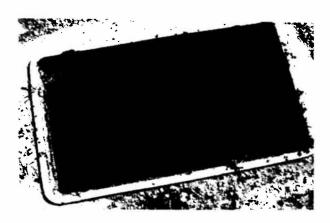
D. Water problem - sealing or not.

E. Finished box.

SLIDE 5-57



SLIDE 5-58



SLIDE 5-59



REFERENCES: Chapter 4, Traffic Detector Handbook

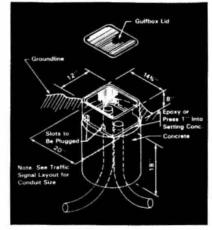
F. Illinois DOT - Gulfbox

5.3.5 LOOP TESTING (2 MINUTES)

Before system is sealed the system should be tested.

- A. Make measurements at the splice box and then at the controller cabinet.
- B. Measure Inductance (within 10% of calculated values).

SLIDE 5-60



SLIDE 5-61



SLIDE 5-62



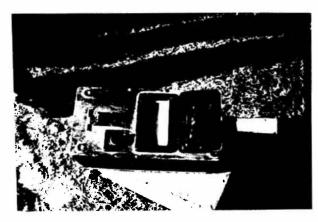
REFERENCES: Chapter 4, Traffic Detector Handbook

C. Resistance to ground (Megger) should exceed 100 megohoms.

D. Series Resistance - reading within 10% of calculated value.

- E. Vehicle Simulator (show from instruction stations) can test to determine if system will detect a small vehicle.
- F. Record readings.

SLIDE 5-63



SLIDE 5-64



SLIDE 5-65



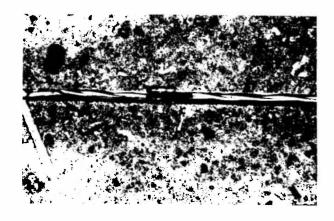
REFERENCES: Chapter 4, Traffic Detector Handbook

5.3.6 SEALING THE LOOP (4 MINUTES)

- A. Use of tie downs is very important.
 - Backer rod
 - Bubble hose (show samples).
- B. Sealant types already covered.
- C. Applicators
 - Poured from bucket.

• Air gun.

SLIDE 5-66



SLIDE 5-67



SLIDE 5-68



REFERENCES: Chapter 4, Traffic Detector Handbook

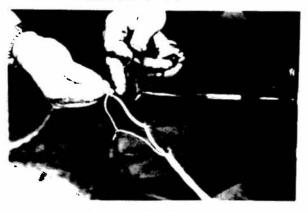
- · Level off.
- D. Encapsulation show test cores
 - its very unlikely that wire will be encapsulated without putting sealant into slot prior to wires.
 - see page 128, Figure 92.
- 5.3.7 WIRE SPLICING (5 MINUTES)
- A. Physical connection
 - solder (ITE)

• crimp

SLIDE 5-69



SLIDE 5-70



SLIDE 5-71



REFERENCES: Chapter 4, Traffic Detector Handbook

stager the crimps

SLIDE 5-72



tape (connection must be strong)

SLIDE 5-73



B. Sealing

wrap

SLIDE 5-74



REFERENCES: Chapter 4, Traffic Detector Handbook

water proofing

SLIDE 5-75



ready for sealant

SLIDE 5-76



Pour Sealant

SLIDE 5-77



REFERENCES: Chapter 4, Traffic Detector Handbook

• Finished Seal

- 5.3.8 LEAD-IN CABLE INSTALLATION (1 MINUTE)
- A. Bury cable in conduit.
- B. Trenching.
- C. Overhead need shielded wire.
- 5.3.9

FINAL TESTS (1 MINUTE)

PAGE 132, FIGURE 97.

SLIDE 5-78



SLIDE 5-79

UNDERGROUND OVERHEAD

SLIDE 5-80



SESSION OVERVIEW

SESSION 7 Wednesday 9:30 - 10:00 A.M.

30 minutes

SESSION TITLE:

MAGNETOMETER INSTALLATION

SYNOPSIS:

This session discusses the considerations of installing magnetometer detectors. The student will identify locations where the detector can best be used and where it cannot be used.

LEARNING OBJECTIVES:

To understand the basics involved in installing magnetometers.

SESSION OUTLINE:

| <u>Schedule</u> | Major Topic | | Time in Minutes |
|-----------------|------------------------|------------|-------------------------|
| 7.1 | Introduction | | 1 |
| 7.2 | Preliminary Planning | | 3 |
| 7.3 | Site Selection | | 6 |
| 7.4 | Installation Procedure | | 20 |
| | | Total Time | $\overline{30}$ minutes |

REFERENCE:

Traffic Detector Handbook, Chapter 4 pages 127 to 134.

EQUIPMENT AND MATERIALS:

In addition to the chalkboard, slide projector and screen, the instructor will need to use the equipment at station number two.

REFERENCE: Chapter 4, Traffic Detector Handbook.

7.1 INTRODUCTION (1 MINUTE)

Session 7: Magnetometer Detector Installation

This session includes the installation of magnetometers. We will discuss

- Preliminary Planning
- Site Selection
- Wire size & cable selection
- Installation details

7.2 PRELIMINARY PLANNING
(3 MINUTES)

SLIDE 7-1



SLIDE 7-2



SLIDE 7-3

PLANNING

- DRAWING
- FIELD VISIST
- EQUIPMENT
- MATERIALS

REFERENCE: Chapter 4, Traffic Detector Handbook.

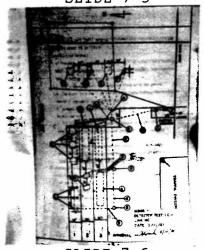
A. Drawing show geometry,

sensor locations, conduit, utilities, pavement composition.

- B. Field Visits Made before and after drawing made; purpose is to determine: (p. 109).
 - 1. Field conditions
 - Utility locations
 - Controller
 - 2. Locate sensors
 - Strategy for burying cable
 - 4. Equipment necessary

SLIDE 7-4 DRAWING

SLIDE 7-5



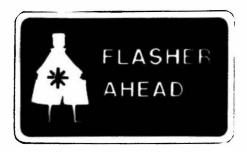
SLIDE 7-6 FIELD VISIT

SLIDE 7-7
EQUIPMENT

REFERENCE: Chapter 4, Traffic Detector Handbook.

5. Traffic Control Strategy

SLIDE 7-8



C. Equipment Required (p. 110)

Same equipment as for loop installation

7.3 SITE SELECTION (6 MINUTES)

- These detectors will detect vehicles whenever a sufficiently intense portion of its magnetic shadow falls on a probe.
- Number of probes is determined by the lane geometry and type of vehicles to be detected. (Page 133)
- A magnetometer will operate properly at latitudes north and south of the narrow equational band.
- Areas to avoid are: (page 134).

SLIDE 7-9 MATERIALS

SLIDE 7-10

- SITE SELECTION
- PROBE PLACEMENT
- PROBE DEPTH
- CONFIGURATIONS

SLIDE 7-11

- SITES TO AVOID
- MANHOLES
- HIGH CURRENT LINES
- TUNNELS

REFERENCE: Chapter 4, Traffic Detector Handbook.

 A magnetic field analyzer can be used to determine where the probes will best operate. It measures the intensity of the magnetic environment.

- Most sites do not possess magnetic noise sufficiently intense (greater than 5 millioersteds) to detract from the magnetometer system performance.
- Few disturbance generating sources are of sufficient intensity to affect a probe located more than 30 feet from the source.

A. Probe Placement

- Maximum probe spacing is equal to the width of the narrowest vehicle to be detected.
- 2. A single probe could be placed in a 10 foot lane but would not be adequate for 12 foot lanes. Two are required.
- In general, detection quality improves as the number of probes per lane is increased.

SLIDE 7-12



SLIDE 7-13



SLIDE 7-14
PROBE PLACEMENT

REFERENCE: Chapter 4, Traffic Detector Handbook.

B. Probe Depth

- 1. Deep placement such as 18 to 24 inches provides good single count detection, but results in lower signal levels.
- Conversely shallow placement gives higher signal levels but tends to provide multiple counts because it detects major components of vehicles.

C. Configurations

- Appendix C shows many different configurations of number of probes and probe depth.
- Configurations are shown for detection of autos, trucks, motorcycles, and bikes.
- Configurations are shown for left turn lanes.
- These can be studied at a later time.

7.4 INSTALLATION PROCEDURES (20 MINUTES)

A. Layout

SLIDE 7-15

PROBE DEPTH

SLIDE 7-16
SUGGESTED CONFIGURATIONS

SLIDE 7-17



REFERENCE: Chapter 4, Traffic Detector Handbook.

and mark detection area.

SLIDE 7-18



B. Drill holes

SLIDE 7-19



and saw slots of cable.

SLIDE 7-20



REFERENCE: Chapter 4, Traffic Detector Handbook.

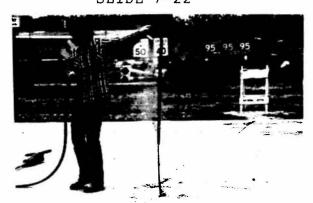
C. Blow out and dry saw slots

SLIDE 7-21



and boring hole.

SLIDE 7-22



Load bearing box

SLIDE 7-23



REFERENCE: Chapter 4, Traffic Detector Handbook.

Trench

SLIDE 7-24



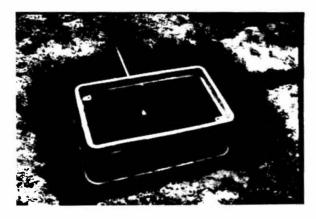
 Concrete foundation which does not allow water to drain out.

SLIDE 7-25



Conduit placed in box.

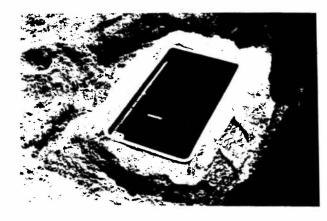
SLIDE 7-26



REFERENCE: Chapter 4, Traffic Detector Handbook.

 Box placement complete with concrete.

SLIDE 7-27



E. Drill holes for conduit.

SLIDE 7-28



Here the holes are complete.

SLIDE 7-29



REFERENCE: Chapter 4, Traffic Detector Handbook.

F. Place conduit from pavement to splice box.

G. Place conduit from splice box

to controller cabinet.

SLIDE 7-30



SLIDE 7-31



SLIDE 7-32



REFERENCE: Chapter 4, Traffic Detector Handbook.

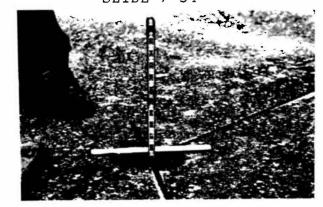
H. Clean out bore hole.

SLIDE 7-33



I. Insure that hole is at the proper depth.

SLIDE 7-34



J. Place one inch PVC in bore hole.

SLIDE 7-35



REFERENCE: Chapter 4, Traffic Detector Handbook.

K. Cover PVC conduit and place concrete around conduit.

- L. Set probe in conduit.
 - Probe <u>must</u> be firmly supported so that they will not shift.
 - Put sand on top of probe.

- M. Use a volt ohmmeter to check the series resistance of probe and cable at splice box.
 - Check for resistance to ground. Value should be high. DON'T USE A MEGGER TO CHECK RESISTANCE TO GROUND as induced voltage will destroy the probe.
- N. Splice and seal.

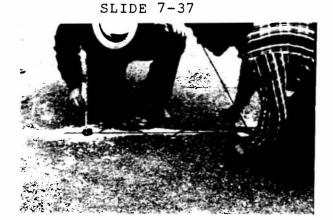
SLIDE 7-36

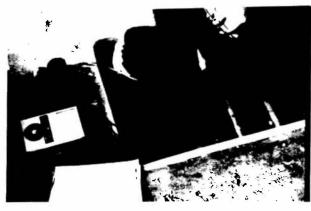
Standard Drawing for Magnetometer Installation

3" Loop Seeler

Concrete Mix #6

1" Diameter (PVC)





REFERENCE: Chapter 4, Traffic Detector Handbook.

O. Test again at controller cabinet and record.

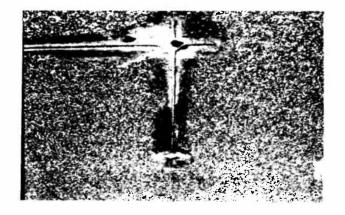
- P. Make an operational check
 - Calibrate unit.
 - Take yard stick and magnet at probe and move magnet along yard stick from top to bottom until unit shows an actuation.
 - Record distance.
- Q. Apply sealant to probe and lead-in areas.

SLIDE 7-39



SLIDE 7-40 OPERATIONAL CHECK

SLIDE 7-41



REFERENCE: Chapter 4, Traffic Detector Handbook.

If it doesn't work??

SLIDE 7-42



BLANK SLIDE

SESSION OVERVIEW

SESSION 9 Wednesday 10:30 - 11:00 A.M. 30 minutes

SESSION TITLE:

MAGNETIC DETECTOR INSTALLATION

SYNOPSIS:

This session discusses the installation of magnetic detectors. Both the open trench method and the tunnelling methods are addressed.

LEARNING OBJECTIVES:

To understand the basic procedures of installing a magnetic detector.

SESSION OUTLINE:

| Schedule | Major Topic | | Time in Minutes |
|----------|----------------------|------------|-------------------------|
| 9-1 | Introduction | | 1 |
| 9-2 | Preliminary Planning | | 3 |
| 9-3 | Locating Detector | | 4 |
| 9-4 | Placement of Conduit | | 12 |
| | | Total Tiem | $\overline{20}$ minutes |

REFERENCE:

Traffic Detector Handbook, Chapter 4, pages 134-141.

EQUIPMENT AND MATERIALS:

In addition to the chalkboard, slide projector and screen, the instructor will need to use the equipment at station number one.

REFERENCE: Chapter 4, Traffic Detector Handbook.

9.1 INTRODUCTION (1 MINUTE)

Session 9: Magnetic Detector Installation

This session includes the installation of magnetic detectors via the open trench and tunneling method.

9.2 PRELIMINARY PLANNING (3 MINUTES)

- A. Drawing shows geometry, sensor locations, conduit, utilities, pavement composition.
- B. Field Visits before and after drawing made. Purpose to determine:
 - Exact location of sensors,
 - Exact size of area coverage,
 - Location of conflicting utilities like manholes, electrical lines, gas lines, etc.,
 - Location of electrical tie-ins,
 - Location of controller cabinet,

SLIDE 9-1



SLIDE 9-2

PLANNING

- DRAWING
- FIELD VISITS
- EQUIPMENT
- MATERIALS

SLIDE 9-3 DRAWING

SLIDE 9-4 FIELD VISITS

REFERENCE: Chapter 4, Traffic Detector Handbook.

- The strategy for burying feeder cables,
- Types of equipment necessary for installation,
- 8. Time of day best suited for installation,
- Method of traffic routing and control,
- 10. Position and quantity of barricades, needed for traffic control and
- 11. Determine necessary
 permits and licenses
 required for
 installation.
- C. Equipment Required
 (page 110)
 - 1. Backhoe
 - 2. Horizontal boring machine
 - 3. Power saw
 - 4. Level
 - 5. Wooden expandable rule
 - 6. 100 foot measuring tape
 - 7. Tamping machine
 - 8. Soldering iron
 - 9. Equipment for rodding cable
 - 10. Traffic control devices
- D. Material Requirements

SLIDE 9-5 EQUIPMENT

SLIDE 9-6
MATERIALS

REFERENCE: Chapter 4, Traffic Detector Handbook.

- 1. Sensors
- 2. Lead-in cable
- 3. Splice boxes
- 4. Splice kits
- 5. Conduit
- 6. Surge voltage protectors
- 7. Solder

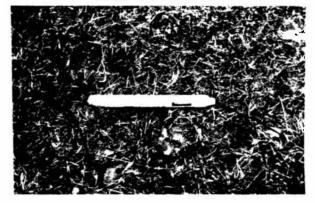
9.3 LOCATING DETECTOR (4 MINUTES)

- Show probe from Station 1
- Placement is important to proper operation

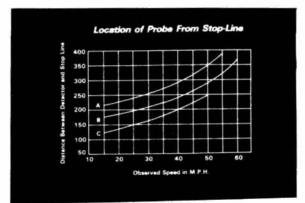
A. Distance from stop line

- Must be travelling greater than 5 mph to detect.
- 5 seconds of travel time from sensor to stop line.
- Street (35 mph) = 257 feet.
- This chart is distributed by manufacturer. Explain slide.

SLIDE 9-7



SLIDE 9-8



REFERENCE: Chapter 4, Traffic Detector Handbook.

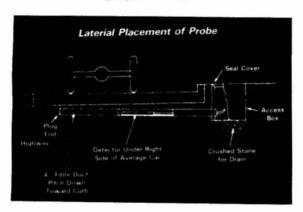
B. Lateral Placement

- Under right wheel track of vehicle.
- Two lane approach place under lane line. (page 10, Figure 9)
- In many cases on two lane approach a probe is placed in each lane.
- When placing probes under new pavement - one sensor per conduit however when placing under existing two sensors per conduit.
- When two or more probes are used on different approaches of the same signal phase, they should be located in similar locations so that all sensors can be adjusted by a single adjustment knob.

9.4 PLACEMENT OF CONDUIT (12 MINUTES

Two methods

SLIDE 9-9



SLIDE 9-10 PLACEMENT OF CONDUIT

- TRENCHING
- DRILLING

REFERENCE: Chapter 4, Traffic Detector Handbook.

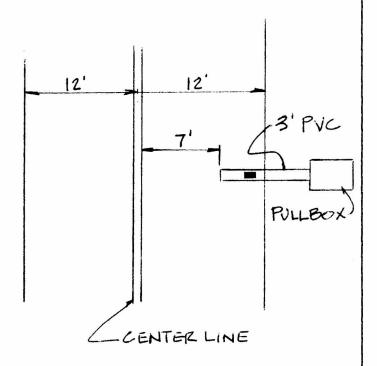
- A. Trenching (from Lionel Rodgers Conn.)
 - 1. Locate placement area.

Courtesy of Bob Nichols NYSDOT.

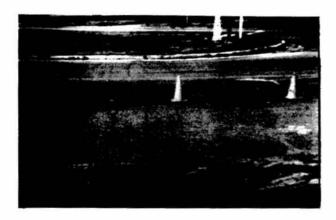
Sensitivity normally turned all the way up.

Probe has a pick-up radius for cars and trucks of 11 feet, motorcycles - 7' radius.

He extends PVC 5' into the roadway so that later he can push probe out further if needed to pick up MC. However, this may cause splashover from adjacent lane.



SLIDE 9-11



REFERENCE: Chapter 4, Traffic Detector Handbook.

Cut pavement

Excavate including area for splice box

- 4. Place conduit; cap end of
 conduit -
 - Cover with 6 inches of concrete
 - If placed in asphaltprobe should be 1 foot deep and covered with sand on bottom and top.

SLIDE 9-12



SLIDE 9-13



SLIDE 9-14



REFERENCE: Chapter 4, Traffic Detector Handbook.

- - Preferred method because does less damage to road.
 - Whenever possible many agencies find it desirable to install from the median area because these areas have fewer sign posts, guardrails and utility activities.
 - Measurement made from splice box to point where conduit should end.

 Drilling machine lowered into trench (2 feet deep, 10 feet long).

SLIDE 9-15



SLIDE 9-16



SLIDE 9-17



REFERENCE: Chapter 4, Traffic Detector Handbook.

3. The bit is leveled before boring begins.

SLIDE 9-18



4. The hole is complete.

SLIDE 9-19



5. Trench is back filled and tamped to a level up to just below the bore hole.

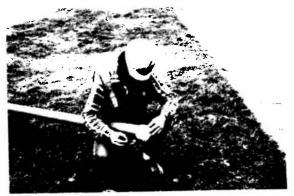




REFERENCE: Chapter 4, Traffic Detector Handbook.

6. The end of conduit is capped.

SLIDE 9-21



7. Conduit is placed in bore hole.

SLIDE 9-22



8. Stone base is placed for splice box.

SLIDE 9-23

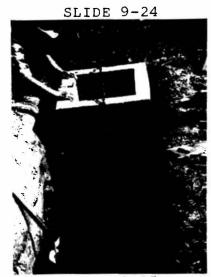


REFERENCE: Chapter 4, Traffic Detector Handbook.

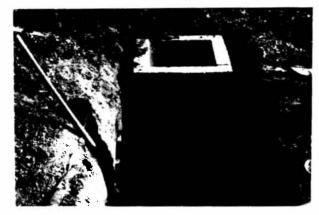
9. Splice box placed in trench.

10. Conduit tied into splice box.

11. The lead-in wires are
 used to measure the
 correct position of
 sensor and wire
 marked.



SLIDE 9-25



SLIDE 9-26



REFERENCE: Chapter 4, Traffic Detector Handbook.

12. The sensor is placed into conduit and pushed into place using a steel wire.

13. Lead-in wires spliced to home run cable.

Because of low signal voltages, excellent splicing is absolutely necessary to clean operation.

- 14. Lead-in cable should be run in conduit for best protection.
- 15. Run only lead-in cable in conduit. Don't put signal cable in conduit. Leakage between wires can cause erratic operation.
- 16. Electrical Tests
 - Series 3800 ohms for 1 probe.
 - Ground several megohms

SLIDE 9-27



SLIDE 9-28



SLIDE 9-29

LEAD-IN CABLE RUN IN CONDUIT

SLIDE 9-30

- ELECTRICAL TESTS
- SERIES RESISTANCE
- GROUND RESISTANCE

SESSION 9. MAGNETIC DETECTOR INSTALLATION

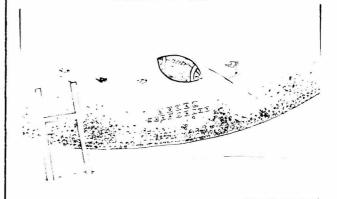
REFERENCE: Chapter 4, Traffic Detector Handbook.

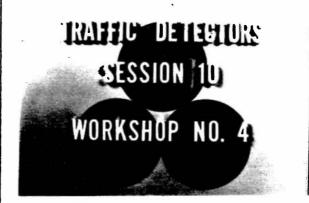
- 17. Set gain on amplifier to lowest value that will work. Casing deteriorates and gain must be increased to make work with time.
- 18. Record all readings.

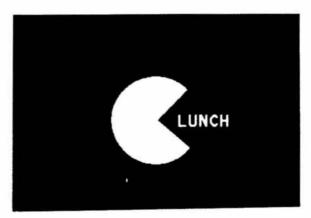
SLIDE 9-31

RECORD ALL READINGS

SLIDE 9-32







SESSION OVERVIEW

SESSION 11 Wednesday, 12:30-1:00

30 minutes

SESSION TITLE:

FINE POINTS OF ILD THEORY AND HARDWARE

SYNOPSIS:

This session presents aspects that can be postponed until after the Workshop Sessions have begun. This material is not vital to an understanding of the exercises at the Instruction Stations. The session covers the calculation of the inductance of a quadrupole loop; the "current sheet" formula for loop inductance; inductance of multiple loops; needed number or turns; loop quality factor "Q", L of multi-loop designs; the influence of reinforcing steel; and the loss of sensitivity from pavement overlays.

LEARNING OBJECTIVES:

Upon completion of this session the participant should be able to apply a number of principles that pertain to advanced applications not necessarily found in everyday practice. He will also acquire some background that will strengthen his confidence in his understanding of applications of many kinds.

SESSION OUTLINE:

| Schedule | Major Topic | Time in Minutes |
|----------|---|--------------------|
| 11.1 | Introduction | 2 |
| 11.2 | Inductances of Quadrupole Loops | 3 |
| 11.3 | Inductance from Current Sheet Formula | 3 |
| 11.4 | Inductance of Multiple Loops | 5 |
| 11.5 | Needed Number of Turns | 2 |
| 11.6 | Loop Quality Factor "Q" | 2 |
| 11.7 | L of Multi-Loop Designs | 7 |
| 11.8 | Influence of Reinforcing Steel | 3 |
| 11.9 | Loss of Sensitivity from Pavement Overlay | _3 |
| | Total Time | 30 minutes |

REFERENCE: Traffic Detector Handbook, Chapter 2, Appendix A and Chapter 6.

EQUIPMENT AND MATERIALS: Chalkboard, slide projector and screen.

REFERENCES: Chapter 2, Appendix A and Chapter 6.

11.1 INTRODUCTION (2 MINUTES)

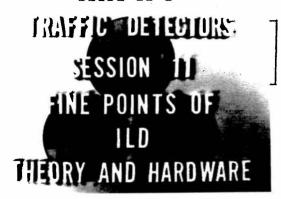
- A. Title of Session 11:

 "Fine Points of ILD Theory and Hardware"
- B. Purpose of Session 11: To present aspects that can be postponed until after the Workshop Sessions begin. This material is not vital to an understanding of the exercises at the Instruction Stations. The session presents a number of principles pertaining to advanced applications not necessarily encountered in everday practice. It also adds some background that will help build confidence in one's understanding of applications of many kinds. Session ends with a practical problem that makes use of the principles covered.

11.2 INDUCTANCE FROM "CURRENT SHEET" FORMULA (3 MINUTES)

- A. Users needing to determine inductances of single loops not found in Table 2 can use the "current sheet" formula in Appendix A beginning on page 189.
- B. Briefly go over Appendix A.
- 11.3 INDUCTANCE OF MULTIPLE LOOPS (5 MINUTES)
- A. Series connection (p.24)

SLIDE 11-1



SLIDE 11-2

INDUCTANCE FROM "CURRENT SHEET" FORMULA

SLIDE 11-3

 $L = L_1 + L_2$

REFERENCES: Chapter 2, Appendix A and Chapter 6.

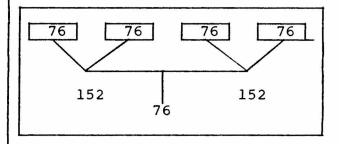
B. Parallel connection (p.25)

- C. Series/parallel connection
 (p.25)
 - 1. Slide 11-6 is similar to Fig. 27.
 - Sensitivity is identical as long as loops are wired equally.
 - 3. Later in this hour we will say more about the sensitivity of multi-loop designs (p. 27, 28)
- 11.4 NEEDED NUMBER OF TURNS (2 MINUTES)
- A. Rule of thumb (p.25)
 - 1. At least 2 turns needed to detect small vehicles.
- B. Effect of increasing turns
 (p.25)
 - 1. Detector units responding to Δ L/L
 - 2. Units responding to ΔL
- 11.5 LOOP QUALITY FACTOR
 "Q" (2 MINUTES)
 - A. "Q" has to do with dissipation of energy as for example by using skinny wire. Think of these energy losses as coming from a resistor in parallel with the loop. Show reference sheet which indicates that Q varies to a point with frequency.

SLIDE 11-4

$$\frac{1}{L} = \frac{1}{L_1} + \frac{1}{L_2}$$

SLIDE 11-5



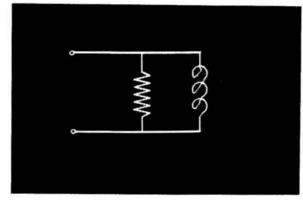
SLIDE 11-6

| Loop Perimeter | Turns |
|----------------|-------|
| Under 30 | 3 |
| Over 30 | 2 |

SLIDE 11-7

DETROIT INCREASED TURNS FROM 3 TO 7

SLIDE 11-8



REFERENCES: Chapter 2, Appendix A and Chapter 6.

11.6 L OF MULTI-LOOP
DESIGNS (7 MINUTES)

- A. Two axioms (p. 27)
- B. CALTRANS example (pp. 27-28). The 190 nh is constant, no matter what wire is connected to that loop.
- C. With four loops wired in any way (p.28).
- D. With lead-in (p.28)

 1. Principle: If lead-in is added then the signal seen by the detector will be reduced by a factor calculated as the equivalent loop inductance divided by the total inductance.
 - Series connection.
 Inductances are additive, so the sum of the loop inductances is so great that the effect of the lead-in is minimized.
 - 3. Series/parallel connection (p. 28)
 Equation shows that the lead-in diminishes the signal at the detector more than with series connection.

SLIDE 11-9

TWO AXIOMS

SLIDE 11-10

HONDA 100 PRODUCES 79 uh x 0.24% = 190 nh

SLIDE 11-11

$$\frac{\Delta L_{t}}{L_{t}} = \frac{1}{4} \left(\frac{190 \text{ nh}}{79 \text{ uh}} \right) = 0.06\%$$

SLIDE 11-12

$$\frac{\Delta L_{t}}{L_{t}} = \frac{1}{4} \left(\frac{\Delta L_{A}}{L_{A}} \right) \left(\frac{4L_{A}}{4L_{A} + L} \right)$$

SLIDE 11-13

$$\frac{\Delta L_{t}}{L_{t}} = \frac{1}{4} \left(\frac{\Delta L_{A}}{L_{A}} \right) \left(\frac{L_{A}}{L_{A} + L} \right)$$

REFERENCES: Chapter 2, Appendix A and Chapter 6.

11.7 INFLUENCE OF REINFORCING STEEL (2 MINUTES)

- A. Work by Mills. (p.28)

11.8 LOSS OF SENSITIVITY FROM PAVEMENT OVERLAY (3 MIN)

A. Overlays typically 3 to 5 inches reduce sensitivity 20 to 30 percent (Fig. 36, p.43)

11.9 SAMPLE PROBLEM (8 MIN)

- A. The objective is to calculate the percent change in inductance for a loop/leadin system for the smallest registered vehicle and compare it to the sensitivity threshold of the selected ILD detector.
 - 1. The system is 4 6ft. x 6ft. 3 turn loops with 600 feet of lead-in.
 - 2. Table 13 shows that the expected percent change in inductance is .06% for series/parallel connections. Expected inductance = 80 microhenries.
 - 3. 600 feet of lead-in adds
 6 x 23 or 130 microhenries to system.
 - 4. Equation 2 shows that the effect of lead-in is to reduce the change in inductance by motorcycle from 0.6% to:

.06 x
$$\frac{80}{80 + 130}$$
 = .023 percent

SLIDE 11-14

STEEL MESH CAN REDUCE LOOP SENSITIVITY BY HALF

SLIDE 11-15

OVERLAYS REDUCE SENSITIVITY BY 20 to 30 PERCENT

REFERENCES: Chapter 2, Appendix A and Chapter 6.

- 5. If the ILD detector has a sensitivity threshold of .03% it is not sensitive enough to detect the motorcycle. We could find an ILD detector with a threshold of .02% but the margin for error would be very small.
- 6. Try another wiring configuration split the four loops into two sets of two and wire in series. From Table 13:

.12 x
$$\frac{158}{158 + 130}$$
 = .066

This provides a comfortable margin of error.

- B. Consider that an overlay will be placed on the loop area.
 - 1. In the first example if an ILD detector with a .02% threshold is specified, the initial solution of parallel/series connection would be satisfactory.
 - 2. If a 3-inch overlay was to be placed over the loop in the future, Figure 119 shows that we will have a 20% reduction in sensitivity. So the 0.23% would be reduced to .0184%.
 - 3. However if the second configuration was used, the 20% reduction would result in a sensitivity of .053% which allows for a good margin of safety.
 - 4. A good sensitivity margin might be 30 percent.

REFERENCES: Chapter 2, Appendix A and Chapter 6.

- C. Analysis for modern digital detectors. Digitals can operate satisfactorily with four loops wired in series rather than series/parallel. Table 13 gives an inductance of 312 microhenries. Older detectors can tune to this level of inductance, but may not detect small vehicles satisfactorily.
 - 1. Table 13 shows for four loops in series .06% change of inductance. The effect of the leadin is now

.06 x
$$\frac{312}{312 + 130}$$
 = .042 percent

This is also shown on Figure 32 on page 38.

- The higher inductance of the loop system tends to swamp out the effect of the lead-in.
- 3. Therefore a single digital detector is adequate and has an ample margin of safety for future overlays.

SESSION OVERVIEW

SESSION 13 Wednesday 1:30 - 2:00 P.M.

30 minutes

SESSION TITLE:

DETECTOR APPLICATIONS AT SIGNALIZED INTERSECTIONS

SYNOPSIS:

This is the first of three 30-minute sessions with the same title. Prior to presenting the material related strictly to signalized intersections, the session begins with some general information pertaining to applications of all types. This introductory material explains the distinction between presence and passage detection and then continues with a brief summary of the applications of the three types of detectors. The main thrust of the session is the detectorization of low-speed approaches to signalized intersections. This topic is extensive and runs into the next session.

LEARNING OBJECTIVES:

The participant learns to choose from among the three detector types on the basis of whether passage (motion) or presence detector is required. The participant also becomes able to design detection for low-speed approaches to signalized intersections that have controllers operating in either the locking or non-locking detection-memory mode. (However, the final topic entitled "Design Layout of Detector Loops" must be postponed to the next lecture session (16).

SESSION OUTLINE:

| Schedule | Major Topic | Time in Minutes |
|----------|---------------------------------|-------------------------|
| 13-1 | Introduction | 10 |
| 13.1 | Signalized Intersection Control | |
| 13.1.1 | Low-Speed Approaches | 20 |
| | Total Time | $\overline{30}$ minutes |

REFERENCE:

Traffic Detector Handbook, Chapter 3, pp. 67-72.

EQUIPMENT AND MATERIALS:

Chalkboard, slide projector and screen.

REFERENCE: Chapter 3, pp. 67-72

13.1 INTRODUCTION (10 MINUTES)

- A. Title of Session 13:
 "Detector Applications at Signalized Intersections"
- B. Purpose of session:
 To present techniques for
 the detectorization of lowspeed approaches to signalized intersections. First,
 however, we will discuss the
 difference between presence
 and passage detection, and
 briefly summarize the
 applications of the three
 types of detectors.
- C. Passage and presence detection (p. 67)
 - 1. Emphasize only "passage
 detector" and "continuous
 - presence detector"
 - The ILD is not a true "continuous presence" detector, as the call will be dropped by the environmental-drift tracking circuitry.
 - The magnetic detector requires motion, so is a passage detector. The loop and magnetometer will detect either moving or motionless vehicles; this is inherent in their design and does not require that the user select which he wants on the front panel.

SLIDE 13-1

SESSION 13 DETECTOR APPLICATIONS AT SIGNALIZED INTERSECTIONS

SLIDE 13-2

PASSAGE VS. PRESENCE REFERENCE: Chapter 3, pp. 67-72

- 2. A passage detector cannot be used in the vicinity of the stopline, as speeds may be too low there for positive detection.
- D. Applications of three types of detectors (p. 68)
 - Magnetic detector can report the arrival of a vehicle.
 - The device receiving the report can make the signals change and/or it can count the volume arriving.
 - If a count is required, the detector must be placed where flow is always free, upstream of queue.
 - Magnetometer detector, also, can be used to report arrival or for counting.
 - 3. ILD, also, can be used to report arrival or for counting, but in addition is economical for determining that there is a vehicle within some large area, usually near the stopline.
 - 4. We will be discussing the detection needed by various types of controllers, such as basic full-actuated and density designs, and we will be careful always to make clear whether the controller is being operated "locking" or "non-locking".

SLIDE 13-3

APPLICATIONS OF THREE TYPES OF DETECTORS SESSION 13. DETECTOR APPLICATIONS AT SIGNALIZED INTERSECTIONS

REFERENCE: Chapter 3, pp. 67-72

5. We will cover the application of detectors that stretch or delay a call (in a later session).

ELEMENT 13.1 SIGNALIZED INTERSECTION CONTROL

Detection strategy at individual signalized intersections depends on approach speed.

14.1-1 LOW-SPEED APPROACHES (20 MINUTES)

Approaches with speeds less than 35 mph are "low-speed". The controller's detection memory can be set by the user to "locking" or "non-locking".

- A. Controllers with locking detection memory (p. 68).
 1. Definition
 - 2. Use with basic actuated controllers
 - Definition
 - Detector placement for full-and semi-actuated controllers (Table 6)
 - Explain need for calling detectors
 - Explain why a single small-area detector near the stopline, normal calling, does not properly take the place of the loop 120' back plus the calling detector.

SLIDE 13-4

LOW-SPEED APPROACHES
TO SIGNALIZED
INTERSECTIONS

SLIDE 13-5

LOCKING DETECTION MEMORY

SLIDE 13-6

BASIC ACTUATED CONTROLLERS

SLIDE 13-7

3 or 4 SECONDS OF TRAVEL TIME BUT NOT MORE THAN 120 FEET

REFERENCE: Chapter 3, pp. 67-72

- 3. Semi-actuated control requires screening out of false calls for the green, so locking operation not desirable. Use non-locking mode and long loops.
- B. Controllers with non-locking detection memory (p. 70)
 - Definition of non-locking operation.
 - 2. Large-area detectors and their non-locking controllers are often termed "loop-occupancy controllers."
 - 3. Expressed in broadest terms, loop-occupancy control overcomes the problem of conventional control (that uses small-area detectors and locking controllers). That problem is that conventional control gives no information on the traffic that is between the detector and the stopline.
 - Consider the intersection shown on this slide.

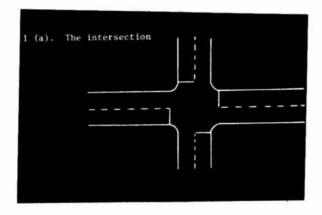
SLIDE 13-8

SEMI-ACTUATED CONTROL REQUIRES SCREENING OUT OF FALSE CALLS

SLIDE 13-9

NON-LOCKING DETECTION MEMORY



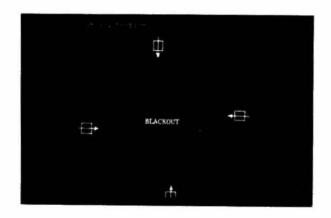


SESSION 13. DETECTOR APPLICATIONS AT SIGNALIZED INTERSECTIONS

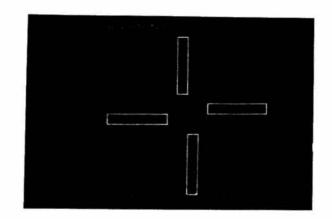
REFERENCE: Chapter 3, pp. 67-72

- The next slide dramatizes the fact that conventional control gives no information between the detector and the stop-The blackout line. means that once a vehicle crosses a small-area detector, its subsequent whereabouts are unknown to the controllers. Therefore, the controller must make assumptions.
- By contrast, the last slide in this series makes it clear that large-area detection is aware of the presence or absence of traffic over a substantial zone upstream of the stopline. The assumptions required of the control strategy are greatly reduced. Consequently, the nonlocking controller can discriminate between a false call and a genuine call for the green. (Example of right turn on red.)
- 4. Use with basic actuated controllers
 - Left-turn lanes (Fig. 42) with separate signal control.
 - Through lanes

SLIDE 13-11



SLIDE 13-12

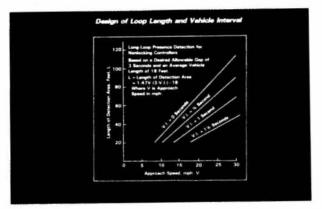


SESSION 13. DETECTOR APPLICATIONS AT SIGNALIZED INTERSECTIONS

REFERENCE: Chapter 3, pp. 67-72

 Length of detection area depends upon the vehicle speed and controller settings. (Figure 43)

SLIDE 13-13



SESSION OVERVIEW

SESSION 15 Wednesday 2:30 - 3:00 P.M.

30 minutes

SESSION TITLE:

DETECTOR APPLICATIONS AT SIGNALIZED INTERSECTIONS

SYNOPSIS:

This session continues the topic begun in the previous lecture session (13). The first few minutes are used to finish the material pertaining to low-speed approaches to signalized intersections. Then high-speed locations are covered, considering both locking and non-locking controllers. Finally, a start is made on the topic of specialized applications at signalized intersections. These pages of the Handbook contain more material than can be presented in the time allotted. The instructor needs to present only selected material and to encourage discussion about it. This is preferable to attempting to shoehorn all of the material into the lecture, leaving no time for questions and comments. The Session Outline below should be of some assistance to the instructor in selecting the material worth emphasizing.

LEARNING OBJECTIVES:

The participant gains more confidence in his/her ability to apply detectors to low-speed approaches to signalized intersections. He/she will also gain some understanding of how to detectorize high-speed approaches, but the actual ability to do it may not come until this session has had some time to sink in.

SESSION OUTLINE:

| Schedule | Major Topic | Time in Minutes |
|----------|-------------------------------------|-------------------------|
| 15-1 | Introduction | 2 |
| 15.1 | SIGNALIZED INTERSECTION CONTROL | |
| 15.1-1 | Low-Speed Approaches | 7 |
| 15.1-2 | High-Speed Approaches | 20 |
| 15.1-3 | Specialized Applications at Signal- | |
| | ized Intersections | 1 |
| | Total Time | $\overline{30}$ minutes |

REFERENCE:

Traffic Detector Handbook, Chapter 3, pp. 72-79.

EQUIPMENT AND MATERIALS:

Chalkboard, slide projector and screen.

SESSION 15. DETECTOR APPLICATIONS AT SIGNALIZED INTERSECTIONS

REFERENCE: Chapter 3, pp. 72-79

15-1 INTRODUCTION (2 MINUTES)

This is a continuation of the last lecture session

ELEMENT 15.1 SIGNALIZED INTERSECTION CONTROL

- A. Title of Session 15:
 "Detector Applications at Signalized Intersections."
- B. Purpose of Session:
 First to finish the material pertaining to low-speed approaches to signalized intersections. Then, high-speed locations are covered, considering both locking and non-locking controllers.
 Finally, a start is made on specialized applications at signalized intersections.

15.1-1 LOW-SPEED APPROACHES (7 MINUTES)

- A. Design layout of detector loops (p. 72).
 - Illinois DOT design leftturn lane.
 - Combination of 80-foot loop length and controller passage time of 1.5 sec. allows for start-up time, queue gaps, short greens and stopping distance.
 - Loop is extended forward of stopline to assure detection.
 - Need for quadrupole.

SLIDE 15-1



SLIDE 15-2

DESIGN LAYOUT OF DETECTOR LOOPS

SESSION 15. DETECTOR APPLICATIONS AT SIGNALIZED INTERSECTIONS

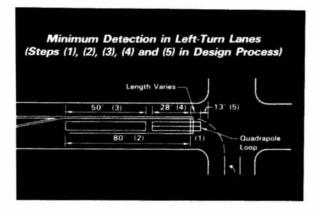
REFERENCE: Chapter 3, pp. 72-79

 Steps in designing minimum left-turn loop in Fig. 44, (p. 73).

15.1-2 HIGH-SPEED APPROACHES (20 MINUTES)

A. Introduction (p. 74). At approach speeds of 35 mph or higher drivers face a zone of difficult decision that is termed a "dilemma zone" in the draft of Chapter 3. The yellow may be ample in duration, so we do not refer to the dilemma described by Gazis around 1960, in which the yellow is so short that the driver caught in the dilemma zone can neither stop nor clear. Our zone is one in which it may be difficult for the driver to decide whether to stop or go through the intersection, although there may be ample yellow time for him or her to do either. abrupt stop may produce a rear-end collision, while a decision to go through on the red may produce a rightangle accident. The boundaries of the zone have been arbitrarily defined in terms of 90% and 10% probability of stopping, as

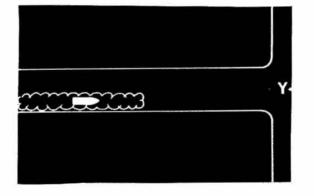
SLIDE 15-3



SLIDE 15-4

HIGH-SPEED APPROACHES

SLIDE 15-5



REFERENCE: Chapter 3, pp. 72-79

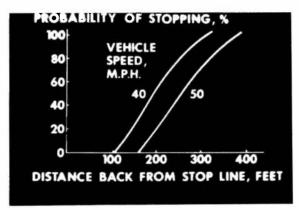
shown in Table 7. These two slides show the zone in two other ways, using the same data as in Table 7.

The graph in slide 15-6 can be entered to show that, at 50 mph, there is a 90% probability of deciding to stop if the driver is about 350 feet from the intersection when the signal goes yellow. The 10% probability can be seen to be about 175 feet back.

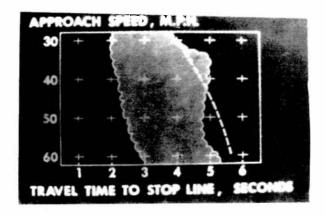
Slide 15-7 shows that the zone is about 2.7 seconds of travel time in length, extending from about 2.3 to 5.0 seconds from the stopline.

- B. A variety of schemes have been devised for controllers with locking and non-locking detection memory, basic and density controllers, and various types of detection.
- C. Controllers with locking detection memory (p. 74).
 - 1. Most straightforward approach is to use a density controller with a small-area detector 5 seconds of travel time from the stopline (such as 386 feet for 55 mph) and a calling detector at the stopline.

SLIDE 15-6



SLIDE 15-7



SLIDE 15-8

DENSITY CONTROLLERS
WITH LOCKING
DETECTION MEMORY

SESSION 15. DETECTOR APPLICATIONS AT SIGNALIZED INTERSECTIONS

REFERENCE: Chapter 3, pp. 72-79

- Explain the trade-off between snappy operation and protection to the slower vehicles in the stream. (pg. 75)
- Don't use "Last Car Passage," as the Trailing Car may be caught.
- D. Controllers with non-locking detection memory (p. 75).
 - 1. These designs always have a long loop at the stopline. We will describe one design that uses basic actuated controller.
 - 2. EC-DC stands for Extended- Call and Delayed Call.
 - 3. EC-DC was made possible by three recent break throughs:
 - Good determinations of the boundaries of the zone of difficult decision.
 - Development of digital controllers that permit the Unit Extension to be tailored to tenths of a second.
 - Loop detectors now available off the shelf with both extended-call and delayed-call features standard.
 - 4. Prior to EC-DC there seemed to be an unmet need for a high-speed design with the following characteristics:

SLIDE 15 -9

BASIC CONTROLLERS WITH NON-LOCKING DETECTION MEMORY

SLIDE 15-10

EC-DC DETECTION FOR HIGH-SPEED SIGNALIZATION

SLIDE 15-11

DIGITAL CONTROLLERS PERMIT THE UNIT EXTENSION TO BE TAILORED TO TENTHS OF A SECOND

SLIDE 15-12
LOOP DETECTORS ARE NOW AVAILABLE
OFF THE SHELF WITH BOTH EXTENDEDCALL AND DELAYED-CALL FEATURES
STANDARD

SESSION 15. DETECTOR APPLICATIONS AT SIGNALIZED INTERSECTIONS

REFERENCE: Chapter 3, pp. 72-79

- Loop occupancy features.
- A basic actuated controller with nonlocking detection memory.
- A short allowable gap, primarily to prevent frequent "max-out" (which may well show a yellow to a vehicle in the zone).
- Protection over a wide range of speeds.
- 5. Explanation of types and locations of the three loops.

6. A description of the operation begins with a start of green. Discharging vehicles produce an unbroken actuation, because of a stretch setting of about 2 seconds on the EC-DC detector. SLIDE 15-13 LOOP-OCCUPANCY FEATURES

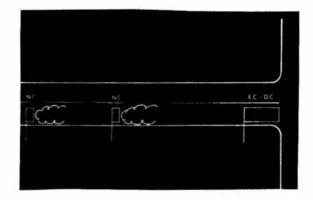
SLIDE 15-14
BASIC ACTUATED CONTROLLER WITH
NON-LOCKING MEMORY

SLIDE 15-15

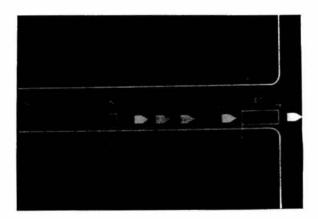
SHORT ALLOWABLE GAP

SLIDE 15-16
DILEMMA-ZONE PROTECTION OVER A
WIDE RANGE OF SPEEDS

SLIDE 15-17



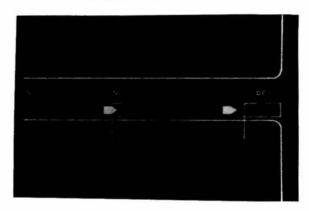
SLIDE 15-18



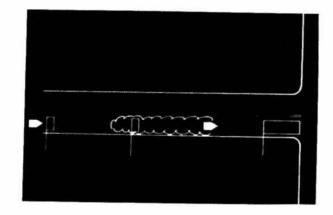
REFERENCE: Chapter 3, pp. 72-79

- 7. By the time discharging traffic is up to speed a two-second gap between vehicles appears. The EC detector at the stopline in effect "gaps out" and becomes a delayed-call unit with about 5 seconds of time delay. The fullspeed vehicles in transit over the stopline loop do not produce a call. The loop has in effect become disconnected, and the continued extension of the green is controlled by the upstream loops and the Unit Extension setting of the controller. If the upstream detectors are operated in the pulse mode, then a unit Extension of 2.2 seconds will "carry" vehicles approaching within the speed range of 40-55 mph though their respective zones of difficult decision.
- 8. This slide shows a gapout of vehicles traveling at 50 mph.

SLIDE 15-19



SLIDE 15-20



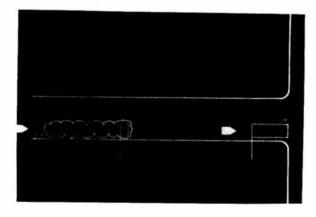
REFERENCE: Chapter 3, pp. 72-79

9. At 40 mph the vehicle does make it through the zone when the yellow comes on upon gap-out.

- 10. The allowable gap of this design is about 4 seconds.
- 11. EC-DC was tested in Georgia in 1978. This slide shows the skid marks present prior to the improvement. The 85th percentile speed here is 54 mph.

12. This is the detection-loop layout.

SLIDE 15-21

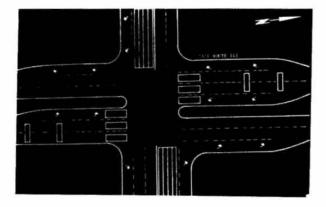


SLIDE 15-22 ALLOWABLE GAP IS ABOUT 4 SECONDS

SLIDE 15-23



SLIDE 15-24



SESSION 15. DETECTOR APPLICATIONS AT SIGNALIZED INTERSECTIONS

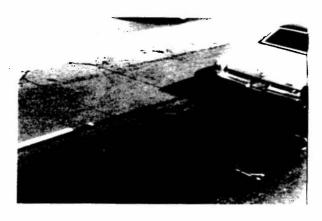
REFERENCE: Chapter 3, pp. 72-79

13. Note that the upstream loops are not extended into the low-speed left-turn lane.

14. The EC-DC stopline loop is short, exposing only a minimum amount of wire to deterioration.

- 15. Three detector units were needed at the time this was designed (1978).
 - The left unit has two channels, each without timing (normal calling). One channel handles all of the upstream detectors on the arterial, and the other is connected to the side-street detectors.

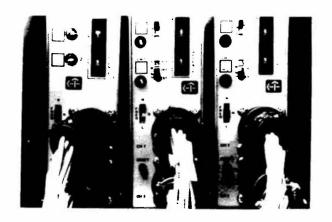
SLIDE 15-25



SLIDE 15-26



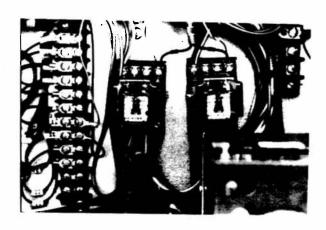
SLIDE 15-27



REFERENCE: Chapter 3, pp. 72-79

- The middle unit is connected to the EC-DC detector on one of the artery approaches, and the right unit is connected to the one on the other approach. Both units have timing. One channel of each unit is set for stretch and the other is set for delay.
- 16. Each of the EC-DC detector units must have a relay on the back panel to switch the loop from one channel to another, from stretch to delay and back and forth.
- 17. If we were implementing EC-DC today we would select a detector unit that automatically goes back and forth from stretch to delay, without any external logic on the backpanel. Examples include the Detector Systems Model 813 at Station 9, and the Sarasota 516T digital units at Station 4.
- 18. Observers counted traffic conflicts and erratic maneuvers on both of the artery approaches, before and after the installation of the EC-DC system. In all, 24 hours of data were obtained. It was found that:
 - o The number of vehicles running the red signal dropped from 12 to 7

SLIDE 15-28



SLIDE 15-29
RUN RED LIGHT BEFORE AFTER
12 7

SESSION 15. DETECTOR APPLICATIONS AT SIGNALIZED INTERSECTIONS

REFERENCE: Chapter 3, pp. 72-79

- Drivers deciding at the last instant to stop fell from 5 to 0.
- Drivers changing their mind, first braking and then deciding to go through, dropped from 8 to 0.
- In all, conflicts were reduced by 69 percent.
- 19. This reduction isn't surprising. Zegeer in Kentucky installed a number of Green Extension Systems that serve a purpose similar to EC-DC but don't have all of its advantages. He measured accidents, not conflicts, before and after and got a 54% reduction.
 - Rear-end accidents fell 75%.
- 15.1-3 SPECIALIZED APPLICA-TIONS AT SIGNALIZED INTERSECTIONS (1 MINUTE)
- A. The vehicle-counting application using volume-density controllers, on p. 77, no longer is important because controllers are no longer offered with the Cars Waiting gap-reduction feature.

Did you get all that!!

SLIDE 15-30
ABRUPT STOP BEFORE AFTER
5 0

SLIDE 15-31
BRAKE BEFORE CLEARING
BEFORE AFTER
8 0

SLIDE 15-32
TOTAL CONFLICTS
BEFORE AFTER REDUCTION
29 9 69%

SLIDE 15-33

ZEGEER OBSERVED A 54 PERCENT REDUCTION IN ACCIDENTS

SLIDE 15-34
REAR-END ACCIDENT ARE REDUCED
75 PERCENT

SLIDE 15-35 SPECIALIZED APPLICATIONS AT SIGNALIZED INTERSECTIONS

SLIDE 15-36

Cartoon

SESSION OVERVIEW

SESSION 17 Wednesday 3:30 - 4:00 P.M.

30 minutes

SESSION TITLE:

DETECTOR APPLICATIONS AT SIGNALIZED INTERSECTIONS

SYNOPSIS:

Session 17 concludes the material pertaining to signalized intersections. Like the previous two lecture sessions (13 and 15) under this same title, there is too much material for the time allowed. Again, it is better to hit the high points and encourage discussion rather than to present an accelerated lecture that covers it all but discourages participation by The quadrupole configuration has already been the group. introduced in the movie and the orientation to Instruction Station 14; that fact will save some time in this session. The detection of small vehicles, including bicycles, deserves the major emphasis. Less detail is necessary in the lecture on the topics that come next, including long-vehicle detection, queue detection, prepare-to-stop-when-flashing applications, and speed control using rest in red. The session ends with a treatment of site-specific factors that tend to favor or disfavor one type of detector over another. This final material is important but does not require much time because largely it has been mentioned in previous sessions.

LEARNING OBJECTIVES:

As a result of this session the participant should have had enough exposure to the quadrupole configuration to be willing to try it in his own jurisdiction. Instructor emphasis on the responsibility to detect the smallest registered motor vehicles should help develop this willingness to give it a try. There will be time to introduce the other applications only to the extend that the participant will know to look up the details in the Handbook should an occasion arise for the use of these specialized techniques.

SESSION OUTLINE:

| Schedule | Major Topic | <u>Time in Minutes</u> |
|----------|--|------------------------|
| 17-1 | Introduction | 2 |
| 17.1 | SIGNALIZED INTERSECTION CONTROL | |
| 17.1-1 | Specialized Applications at | |
| | Signalized Intersections | 23 |
| 17.1-2 | Location-Specific Factors | |
| | Dictating Selection of Detectors Total Tim | $\frac{5}{30}$ minutes |

REFERENCE:

Traffic Detector Handbook, Chapter 3, pp. 79-87.

EQUIPMENT AND MATERIALS:

Chalkboard, slide projector and screen. The instructor is provided with a model of an intersection approach that has six pegs installed so that he/she can use the yarn provided to demonstrate how the quadrupole configuration is laid out in a figure-eight pattern.

Also, before the session begins the instructor should connect an analog ILD with a variable-L bench test loop from Station 4. Set the paddle high enough so that the call will drop after just a few seconds. Use an inductance setting of two to three hundred microhenries, to simulate a long loop.

The instructor will want to practice demonstrating the preformed quadrupole loop at Station 14, using the minimum-vehicle simulator. SESSION 17. DETECTOR APPLICATIONS AT SIGNALIZED INTERSECTIONS

REFERENCE: Chapter 3, pp. 79-87

17-1 INTRODUCTION (2 MINUTES)

This is a continuation of the last lecture session (15).

ELEMENT 17.1 SIGNALIZED INTERSECTION CONTROL

- A. Title of Session 17: "Detector Applications at Signalized Intersections."
- B. Purpose of Session. To conclude the material pertaining to signalized intersections. Major emphasis is given to the detection of small vehicles, including bicycles.

17.1-1 SPECIALIZED APPLICATIONS AT SIGNALIZED INTERSECTIONS (23 MINUTES)

We are continuing this topic from the last lecture session (16).

- A. Small motor-vehicle detection (p. 79).
 - 1. The driver of a registered motor vehicle, however small, has a right to expect to receive the green at a signalized intersection. A presence detector should be able to detect a Honda 70 and hold the call until the green comes.

SLIDE 17-1

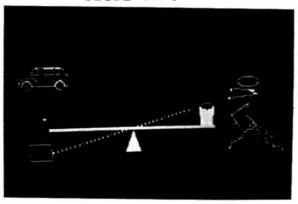
SLIDE 17-2

SMALL MOTOR-VEHICLE DETECTION

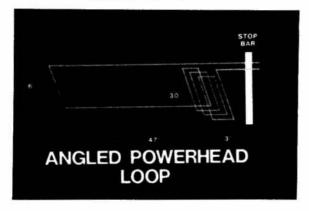
REFERENCE: Chapter 3, pp. 79-87

- California feels that at an 8-phase intersection with heavy volume on all of them, the wait for the green could be as much as 3 minutes.
- 3. Page 45 in the <u>Handbook</u> explained why the circuitry for environmental tracking may "wash" out a weak call in a few seconds.
 - Instructor can demonstrate this using an analog ILD with a variable-L bench-test loop. Set the paddle so high that the call drops after just a few seconds.
- 4. An ordinary long loop will not detect a small motorcycle and hold the call for 3 minutes, so various improved configurations have evolved over the years.
 - The powerheads shown in Figures 49 and 50 were used at one time, as was the chevron configuration shown in Figure 51. These were introduced in the movie we saw on Tuesday.

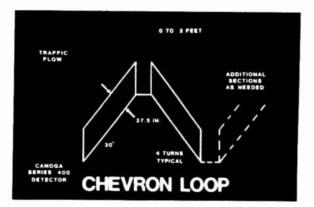
SLIDE 17-3



SLIDE 17-4



SLIDE 17-5



REFERENCE: Chapter 3, pp. 79-87

5. Four small loops can be wired together as presented in Chapter 2, p. 25, Fig. 26. These have a number of advantages over a single long loop with a single powerhead, as expained on p. 80.

EXPLAIN ADVANTAGES

- 6. Currently, the quadrupole configuration enjoys widespread popularity, as it is very sensitive without the disadvantage of splashover (p.81).
 - Instructor should use the yellow yarn to wind a 1-2-1 and a 2-4-2 on the model board provided.
 - Show the preformed quadrupole at Station 14, and demonstrate the sensitivity along the center wires, and the lack of splashover tendency, using the minimum-vehicle simulator.
 - Chapter 2 does not describe how to calculate the inductance of a quadrupole. A 6' x 50', 2-4-2 design with 50 feet of lead-in, constructed in Atlanta, had 450 microhenries as measured by a Safetran meter.

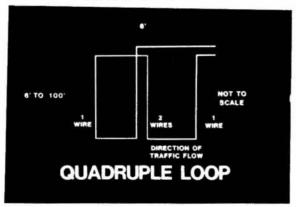
SLIDE 17-6

Advantages of 4 6' x 6' loops.

SLIDE 17-7

- 1. Greater Reliability
- 2. Greater Sensitivity Control
- Optimum Inductance Capability
- 4. Greater Detection Ability

SLIDE 17-8



SESSION 17. DETECTOR APPLICATIONS AT SIGNALIZED INTERSECTIONS

REFERENCE: Chapter 3, pp. 79-87

- B. Bicycle detection (p.82). Especially important at some university campuses.
 - California's type-D loop design.
 - Explain winding detail and sawcut detail.
 - Explain use of two loops, provision of extension time, minimum timing and delay feature to screenout calls from right-turning vehicles.

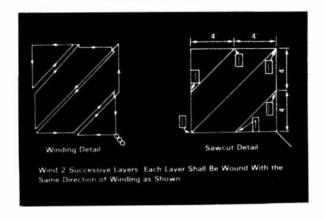
1 loop located = 100'
from cross-walks.
Extension time used to
hold green until he
gets to loop at crosswalk. Extensive time
added to provide for
safe time.

Key is to locate where it will be used by majority of cyclists.

- Butler and Snipes used 8' x 50' quadrupole loops with distinctive pavement markings shown in Figure 54.
- City in California ran an educational campaign to get bicyclists to travel over an appropriate marking (Figure 55).

SLIDE 17-9
BICYCLE DETECTION

SLIDE 17-10



SLIDE 17-11



SLIDE 17-12



REFERENCE: Chapter 3, pp. 79-87

- C. Long-vehicle detection (p. 83).
 - Three reasons why large, heavy trucks should not be stopped if it can be avoided.
 - 2. The 302 feet attributed to Sackman assumes a reasonable 1.17 second for perception-reaction and a reasonable deceleration rate of 10 ft/sec/sec.

"Second loop is activated before the 1st is vacated."

- 3. Explain the two loops and the logic.
- 4. Useful for counting and warning as well as actuating signal controller.
- 5. SCANDI adjustable diamond loops in Detroit. Supplement this material with that on p. 26 and p. 48.
- D. Queue detection (p. 84).
 - 1. Detection of an off-ramp queue threatening to back up to the freeway is most important if the freeway has a sight-distance restriction due to horizontal or vertical curvature or to an obstruction.

SLIDE 17-13

LONG-VEHICLE DETECTION

SLIDE 17-14

Reasons not to stop trucks

- Jack Knife
- Delays to other vehicle after they are stopped due to slow acceleration.
- 3. Noise & air pollution.

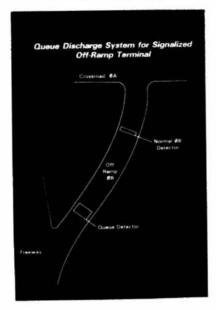
SLIDE 17-15

OUEUE DETECTION

REFERENCE: Chapter 3, pp. 79-87

- Temporary alignments during construction or maintenance may produce such restrictions.
- Explain features on p. 84.
 - The output from the queue detector can be used to disconnect the detectors on the crossroad, forcing a gap-out once the minimum green has timed out. Or it could call for Max 2 for the off-ramp, set higher than Max 1.
- E. Prepare to stop when flashing (p. 84).
 - Explain features on p. 84.
 - 2. The Handbook does not mention Matthews' findings and conclusions. He found that for a few months after the installation of the sign accidents were reduced. Then they began to increase. At one location there were 32 accidents the year before the installation and 50 in the year after. four other locations our experience has been a little better but not much." His conclusion is a classic that deserves a slide of its own. underlining is "emphasis added."

SLIDE 17-16



SLIDE 17-17

PREPARE-TO-STOP ACTUATED SIGNS

SLIDE 17-18

"OUR CONCLUSION IS THAT YOU SHOULD NOT REQURE A DRIVER TO MAKE ANY MORE DECISIONS THAN THAT REQUIRED AT A STANDARD SIGNAL. GIVING THE DRIVER TOO MUCH INFORMATION IS UNDESIRABLE. IT WOULD BE BETTER TO PICK THE BEST AVAILABLE GAP IN TRAFFIC WITHOUT THE DRIVER KNOWING ABOUT IT."

SESSION 17. DETECTOR APPLICATIONS AT SIGNALIZED INTERSECTIONS

REFERENCE: Chapter 3, pp. 79-87

- F. Speed control using rest in red (p. 85).
 - 1. Explain features on p. 85.
 - 2. Atlanta uses this technique successfully. The first loop is accompanied by the sign showed in the slide.
 - First used at a critical S-curve on Peachtree Hills Avenue where accidents had been increasing infrequency.
 - Study showed that speeds dropped by 3 mph on the average, based on large sample. One location dropped from 50 to 43 mph.
 - Accidents dropped 40%, but that was not statistically significant as the "after" period was less than 3 months long.
 - 3. Conner in Los Angeles reduced average speeds by 3 to 5 mph after 6 months of driver familiarity.
- 17.1-2 LOCATION-SPECIFIC FACTORS DICTATING SELECTION OF DETECTORS (5 MINUTES)

SLIDE 17-19

SPEED CONTROL USING REST IN RED

SLIDE 17-20





SLIDE 17-21

Speeds Reduced on Average 3 mph and 7 mph

SLIDE 17-22

LOCATION-SPECIFIC FACTORS DICTATING SELECTION OF DETECTORS SESSION 17. DETECTOR APPLICATIONS AT SIGNALIZED INTERSECTIONS

REFERENCE: Chapter 3, pp. 79-87

The magnetic detector is relatively troublefree because it is rugged and located underneath the pavement. The ILD wire is more fragile and is within the wearing surface. Magnetometers are deep but can malfunction if they tilt slightly from vertical.

- A. Locations where ILD cannot be used (p. 86).
 - Unstable, deteriorated pavements.
 - Bridge decks or reinforced concrete.
 - Where lead-in is 1000 feet or more.
- B. Locations contraindicated for magnetometers (p. 86).
 - Where there are changing magnetic fields, as near subway tracks or sidewalk freight elevators.
 - Near vertical steel members such as columns.
 - Use field strength analyzer such as at Station 2.
- C. Locations favoring magnetic detectors (p. 87).

SLIDE 17-23

LOCATIONS CONTRAINDICATED FOR ILD

SLIDE 17-24

- 1. Unstable Deteriorated Pavement
- 2. Bridge Decksor Reinforced Concrete
- 3. Lead-in >1000 feet.

SLIDE 17-25

LOCATIONS
CONTRAINDICATED
FOR
MAGNETOMETERS

SLIDE 17-26

- 1. Changing Magnetic Fields
- 2. Near Vertical Steel.

SLIDE 17-27

LOCATIONS FAVORING MAGNETIC DETECTORS

SESSION 17. DETECTOR APPLICATIONS AT SIGNALIZED INTERSECTIONS

REFERENCE: Chapter 3, pp. 79-87

• Environmentally severe areas such as Northeast U.S.

 Wherever there is a problem with ILD and magnetometer and you can get by with a motion detector and locking detection memory.

SLIDE 17-28

- 1. Environmentally Severe Areas
- 2. Problem Areas for ILD and Magnetometers

SESSION OVERVIEW

SESSION 19 Thursday 8:30 - 9:00 A.M.

30 minutes

SESSION TITLE:

DETECTOR APPLICATIONS: OTHER LOCAL APPLICATIONS

SYNOPSIS:

This session could well begin with a call for questions and comments about Wednesday's lectures and Workshop Sessions. The time remaining in this 30-minute session is devoted to orientating the participant to several local applications other than traffic detection at signalized intersections. These applications include speed monitoring, traffic counting, vehicle classification, and safety applications such as those at locations where sight distance is restricted by a curve or hill.

LEARNING OBJECTIVES:

The session is too short to allow the participant to leave able to implement all the unusual applications covered in the Handbook, but it is a reasonable objective to familiarize the participant with the fact that there is a solution to many a particular problem. Thus encouraged, the participant will know to look up the details when the occasion arises. Another objective is to bring the participant to the point where he/she understands that there are many unusual problems, in every jurisdiction, that are not specifically covered in this Handbook but which can be solved by the participant who has mastered the fundamental principles of detection. The participant who is imaginative and innovative will find new applications routinely.

SESSION OUTLINE:

| Schedule | Major Topic | Time in Minutes |
|----------|---|----------------------|
| 19.1 | Introduction | 2 |
| 19.2 | Speed Monitoring | 6 |
| 19.3 | Too Fast When Flashing | 6 |
| 19.4 | Traffic Counting and Vehicle | |
| | Classification | 6 |
| 19.5 | Warning Where Sight Distance Restricted | 10 |
| | Total Time | $\overline{30}$ Min. |

REFERENCE:

Traffic Detector Handbook, Chapter 3, pp. 87-93

EQUIPMENT AND MATERIALS:

Chalkboard, slide projector and screen

REFERENCE: Chapter 3, pp. 87-93

19.1 INTRODUCTION (2 MINUTES)

- A. Title of Session 19:
 "Detector Applications:
 Other Local Applications."
- B. Purpose of Session:
 To orient the participant to several local applications other than traffic detection at signalized intersections.
 These applications include speed monitoring, traffic counting, vehicle classification, and safety applications such as those at locations where sight distance is restricted by a curve or hill.

19.2 SPEED MONITORING (6 MINUTES)

- A. Differs from speed measurement in signal systems and on freeways in that here we are interested in individual vehicles, not averages over many vehicles.
- B. Go over advantages, disadvantages of ILD (p. 87)

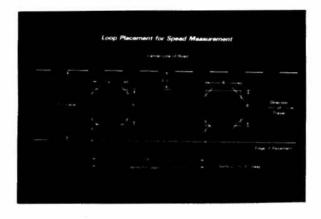
SLIDE 19-1



SLIDE 19-2

TWO LOOPS TO MEASURE SPEED





REFERENCE: Chapter 3, pp. 87-93

- C. The material about intercepts means that the field of the loop can be considered to have a height of one-half of the dimension of the loop in the direction of travel. That is, if that dimension is only 2' then the field rises only 1' and therefore will not be intercepted by many high-bodied vehicles. one-half rule is old, from the days of crystal detectors. Modern analog and digital units operated at high sensitivity have a height of field about equal to the dimension of the loop in the direction of travel (p. 88).
- D. Reference 22, by Ingram, adds more data on pick-up and drop-out times of ILD units. It is important that the two units be matched, or at least consistent, in this characteristics.

19.3 TOO FAST WHEN FLASHING (6 MINUTES)

- A. Speed-actuated signs can be effective when motorists are unfamiliar with the curve or hill because they are not local residents (p. 88).
 - 1. Local drivers have already decided how fast they intend to drive. They will ignore the sign, or perhaps even speed up to make the sign respond to them and give a greeting.



Fine Fine Fine Fine Fine Fine Part Manager Wires

SLIDE 19-4

SLIDE 19-5

"TOO FAST WHEN FLASHING" ACTUATED SIGNS

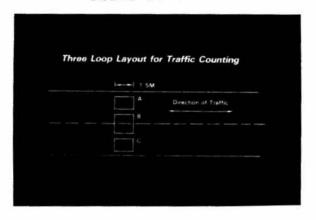
REFERENCE: Chapter 3, pp. 87-93

- B. Commercial loop detectors with stable pick-up and drop-out characteristics can measure speed to within 1 mph (p. 89).
- C. Digital units more stable than analog ones. See discussion of response time on pp. 48-49 (Chapter 2).
- 19.4 TRAFFIC COUNTING AND VEHICLE CLASSIFICATION (6 MINUTES)
 - A. The California portable loop shown in Fig. 59 is not recommended as we cannot find a source of the special wire (p. 90).
 - B. When there are multiple lanes in a direction it is not advisable to extend one loop across all the lanes. Even with the loop in the pulse mode, some undercounting will occur if volumes become heavy. (p. 90)
- C. A three-loop arrangement can be used where lane discipline is not good (p.90).

SLIDE 19-6

LOOPS FOR TRAFFIC COUNTING AND VEHICLE CLASSIFICATION

SLIDE 19-7

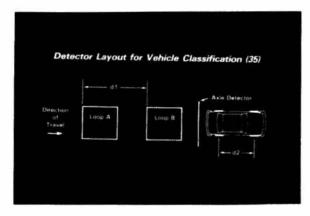


REFERENCE: Chapter 3, pp. 87-93

- D. Detector layout for vehicle classification (p. 91).
 - Uses two loops and an axle detector (which could be a tapeswitch, pnenmatic tube, etc.)

- 19.5 WARNING WHERE SIGHT DISTANCE RESTRICTED (10 MINUTES)
- A. Actuated sign can be used if a signal ahead cannot be seen because of horizontal and vertical curvature (p. 91).
 - 1. Sign upstream begins to flash prior to the amber display. If the controller is actuated this would have to be done using the last car passage feature.
 - Consider using EC-DC instead.
- B. Sometimes the problem is that a signal installation will produce a queue where one never existed before. Driver coming around curve or over hill may encounter queue and have no way to stop. Use queue detector at strategic location (see P. 84) and use output to flash sign upstream of curve (p. 92).

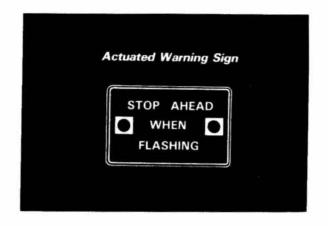
SLIDE 19-8



SLIDE 19-9

WARNING WHERE SIGHT DISTANCE RESTRICTED

SLIDE 19-10



REFERENCE: Chapter 3, pp. 87-93

C. Always consider the consequences when warning sign fails because of breakdown of loop or electronics units on sign. If such a failure might produce a serious accident then you need to consider installing two loops, two detectors, with OR logic transmitting power to two sets of flashers. Also, need regular inspection program (p. 92).

SLIDE 19-11

CONSIDER POSSIBLE NEED TO INSTALL
BACK-UP SYSTEM

SESSION OVERVIEW

SESSION 21 Thursday 9:30 to 10:00 A.M.

30 minutes

SESSION TITLE:

ILD MAINTENANCE

SYNOPSIS:

This session presents procedures for maintaining inductive loop detectors. Certain types of failures are presented and systematic procedures are discussed for rectifying common problems.

LEARNING OBJECTIVES:

Upon completion of this session the participant should be able to understand the types of problems that cause loop systems to fail. They should have a basic understanding of the procedure required to rectify the problems which are likely to occur.

SESSION OUTLINE:

| <u>Schedule</u> | Major Topic | Time in Minutes |
|-----------------|--------------------------------------|-----------------|
| 21.1 | Introduction | 1 |
| 21.2 | Reasons for Failures | 1 |
| 21.3 | Types of Common Problems | 1 |
| 21.4 | Trouble-Shooting Procedures | |
| 21.4-1 | Saw Slot Maintenance | 1 |
| 21.4-2 | Substitution of Units | 1 |
| 21.4-3 | Rearrangement of Loop Configurations | 2 |
| 21.4-4 | Eliminating Crosstalk | 4 |
| 21.4-5 | Operational Checks with | |
| | Maintenance Vehicle | 10 |
| 21.4-6 | Electrical Tests | 4 |
| 21.4-7 | Locked Calls | 4 |
| 21.4-8 | Maintenance Records | 1 |
| | Total Time | 30 minutes |

REFERENCE:

Traffic Detector Handbook, Chapter 5

EQUIPMENT AND MATERIALS:

Chalkboard, slide projector and screen.

REFERENCE: Chapter 5, Traffic Detector Handbook.

21.1 INTRODUCTION (1 MINUTE)

- A. Title of Session 21: "ILD Maintenance."
- B. Purpose of Session 21:
 To present procedures for
 maintaining inductive loop
 detectors. Reasons for
 failures, type of common
 problems and troubleshooting procedures are
 presented.

21.2 REASONS FOR FAILURES (1 MINUTE)

Explain Slide 21-2 (page 149)

21.3 TYPES OF COMMON PROBLEMS (1 MINUTE)

Explain Slide 21-3 (page 150)

21.4 TROUBLE-SHOOTING PROCEDURES

21.4-1 SAW SLOT MAINTENANCE (1 MINUTE

Every six months

SLIDE 21-1



SLIDE 21-2

REASONS FOR FAILURES

- UNIT FAILURE
- CONSTRUCTION
- POOR SEALANT
- PAVEMENT PROBLEMS
- SPLICING
- LIGHTNING SURGES

SLIDE 21-3

TYPES OF PROBLEMS

- NO DETECTION
- CONTINUOUS CALL
- INTERMITTENT CALLS
- CROSSTALK
- SPLASHOVER

SLIDE 21-4

SAW SLOT MAINTENANCE

REFERENCE: Chapter 5, Traffic Detector Handbook.

- Remove deteriorating sealant
- Clean area
- Apply new sealant

21.4-2 SUBSTITUTION OF UNITS (1 MINUTE)

- A. Each unit received from manufacturer must be checked in shop to determine minimum sensitivity under which it will operate.
- B. Substitute unit.
 - If system doesn't work;
 - Put original unit back in and look for another problem.
- 21.4-3 REARRANGEMENT OF LOOP CONFIGURATION (2 MINUTES)
- A. System might not be sensitive enough: Reason
 - Not enough turns of wire
 - Shorted wires
- B. Can bring into proper operating range by adding an inductor either in series or parallel.
 - In multiple loop system a series connection can be used to increase the total inductance.
 - In a single system a small inductor can be placed in series with a loop to increase total inductance.

SLIDE 21-5

Remove Deteriorating Sealant, Clean Area, Apply New Sealant

SLIDE 21-6
SUBSTITUTE UNIT

SLIDE 21-7
REARRANGE LOOP CONFIGURATION

SLIDE 21-8
SERIES CONNECTION WILL
INCREASE INDUCTANCE

REFERENCE: Chapter 5, Traffic Detector Handbook.

26.4-4 ELIMINATING CROSSTALK (4 MINUTES)

- A. When loops and/or lead-in wires are too close and operating close to the same frequency.
 - Change frequency of a channel.
- B. General Procedure
 - 1. Disconnect channels which show most false calls.
 - 2. If no false calls now occur selectively begin to reconnect.
 - 3. Identify problem area.
 - 4. Assign sensors to different channels or retwist lead-ins in splice box or controller cabinet.
- C. Scanning type detectors don't have problem between channels. Might with other detector units.
- 21.4-5 OPERATIONAL CHECKS WITH MAINTENANCE VEHICLES (10 MINUTES)
- A. Adjacent Lane Detection (Splashover)
 - Move close to loop and monitor detector.
 - 2. Adjust sensitivity down.

SLIDE 21-9 CROSSTALK

SLIDE 21-10

CHANGE FREQUENCY

SLIDE 21-11

GENERAL PROCEDURES

SLIDE 21-12

- 1. Disconnect channels
- 2. Selectively reconnect
- 3. Identify problem area
- 4. Reassign sensors to different channels.

SLIDE 21-13
OPERATIONAL CHECKS WITH
MAINTENANCE VEHICLE

SLIDE 21-14
ADJACENT LANE DETECTION

SLIDE 21-15

MOVE CLOSE TO LOOP, ADJUST SENSITIVITY DOWN

REFERENCE: Chapter 5, Traffic Detector Handbook.

- 3. Quadrupole and Diamond loops.
- 4. Use detector with delay time.
- B. Intermittent Operation and Wire Movement
 - Operate Vehicle over loop.
 - Could cause wire to move.
 - 3. Could cause leaks or shorts to ground.
 - These problems are associated with lockup.
- C. Use Vehicle Simulator
 - 1. Determine sensitivity of loop.
 - Make frequency measurement with no vehicle present.
 - 3. Read with simulator in loop.
 - 4. Multiply the % change in frequency f2-f1/f1 x 2 to get % change in inductance.
- 21.4-6 ELECTRICAL TEST (4 MINUTES)
- A. Series resistance
- B. Resistance to Ground take both at controller and splice box.

SLIDE 21-16 QUADRUPOLE DIAMOND

SLIDE 21-17 INTERMITTENT OPERATION

SLIDE 21-18

WIRE MOVEMENT LEAKS OR SHORTS TO GROUND

> SLIDE 21-19 VEHICLE SIMULATOR

> > SLIDE 21-20

MAKE FREQUENCY MEASUREMENT

- 1. No Vehicle Present
- 2. Simulator in Loop

SLIDE 21-21 ELECTRICAL TESTS

SLIDE 21-22

SERIES RESISTANCE RESISTANCE TO GROUND MEASURE INDUCTANCE

REFERENCE: Chapter 5, Traffic Detector Handbook.

- C. Measure Inductance.
- D. Check these values against those taken during installation.
- E. Low ground resistance.
 - Poor insulation
 - Poor splice seal
- F. High Series Resistance
 - Poor Splice
 - Too small gage wire
 - Poor Connections

21.4-7 LOCKED CALLS (4 MINUTES

- A. Record resonant frequency of loop without vehicle.
- B. Monitor frequency when vehicle present.
- C. Look for abrupt changes in frequency when no vehicle present.
- D. Look for decrease in frequency when vehicle present.

If these problems exist the loop or lead-in may not be securely attached to the pavement. Suspect both. Open splice and attach bench test loop to lead-in and monitor at controller cabinet.

If there is no rapid shift in frequency the problem is either in the splice or loop.

SLIDE 21-23 LOW RESISTANCE TO GROUND

SLIDE 21-24 HIGH SERIES RESISTANCE

SLIDE 21-25

LOCKED CALLS

SLIDE 21-26

Abrupt changes in frequency when no vehicle present

Decrease in frequency when vehicle present

REFERENCE: Chapter 5, Traffic Detector Handbook.

Make a new splice. If this does not work replace loop.

21.4-8 MAINTENANCE RECORDS (1 MINUTE)

- A. Reading at controller & splice box.
- B. Recording should be updated during maintenance.
- C. This practice will help identify problem.

SLIDE 21-27
MAINTENANCE RECORDS

SESSION OVERVIEW

SESSION 23 Thursday 10:30 to 11:00 A.M.

30 minutes

SESSION TITLE:

MAGNETOMETER AND MAGNETIC DETECTOR MAINTENANCE

SYNOPSIS:

This session includes the basics of analyzing the magnetometer and magnetic detector should either detector fail to operate. A systematic approach to trouble-shooting is presented. Both of these devices are relatively simple to maintain. The magnetic detector is especially a very durable device and does not often fail.

LEARNING OBJECTIVES:

During this session the participant will learn maintenance techniques for the magnetometer and magnetic detector. Simple step by step procedures are presented which he can quickly learn.

SESSION OUTLINE:

| <u>Schedule</u> | Major Topic | <u>Time in Minutes</u> |
|-----------------|---------------------------------|-------------------------|
| 23.1 | Introduction | 2 |
| 23.2 | System Failures | 5 |
| 23.3 | Trouble-Shooting Procedures for | |
| | Magnetometers | 11 |
| 23.4 | Magnetic Detector/Maintenance | 1 |
| 23.5 | Trouble-shooting Procedures for | |
| | Magnetic Detector | 11 |
| | Total Time | $\overline{30}$ minutes |

REFERENCE:

Traffic Detector Handbook, Chapter 5

EQUIPMENT AND MATERIALS:

Chalkboard, slide projector and screen.

REFERENCE: Chapter 5, Traffic Detector Handbook.

23.1 INTRODUCTION (2 MINUTES)

- A. Title of this session is "Magnetometer and Magnetic Detector Maintenance."
 - These devices are relatively simple to maintain.
- B. Detector Failures
 - Improper installation.
- 23.2 SYSTEM FAILURES (5 MINUTES)

- A. Burial depth important
 - Deep placement (24 inches) yields good single counts
 - Shallow placement (6 inches) yields stronger signal but have greater chance of double counting.
 - Must be at the proper depth for intended application, see Appendix C.

SLIDE 23-1

TRAFFIC DETECTURS
SESSION 23
MAGNETOMETER &
MAGNETIC DETECTOR
MAINTENANCE

SLIDE 23-2 SYSTEM FAILURE

- 1. BURIAL DEPTH
- 2. PROBE MOVEMENT
- 3. PROBE CABLE
- 4. SAW SLOT MAINTENANCE

SLIDE 23-3 SYSTEM FAILURE

- 1. BURIAL DEPTH
- 2. PROBE MOVEMENT
- 3. PROBE CABLE
- 4. SAW SLOT MAINTENANCE

REFERENCE: Chapter 5, Traffic Detector Handbook.

- 1. Evidence of new construction.
- 2. Loose connections
- 3. Poor sealant

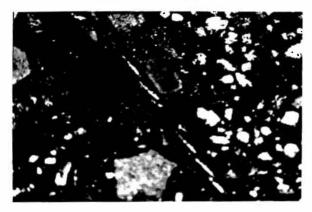
- 4. Exposed wires
- 5. Bad splices

- B. Tilting of Probe
 - Do not retune detector unit.
 - Use bar magnet and yard stick.
 - Start magnet at top of stick and lower until indicator light on detector unit comes on. (use black board)

SLIDE 23-9



SLIDE 23-10



SLIDE 23-11 TILTING

SLIDE 23-12 DO NOT RETUNE

SLIDE 23-13

BAR MAGNET AND YARD STICK

REFERENCE: Chapter 5, Traffic Detector Handbook.

 Check this distance with measurement taken during installation.

- If the distance is smaller; then probe has tilted. Retune unit and frequently monitor.
- The only way to compensate for tilting is to use a Digital Nulling Loop, which is an automatic compensating device.
- This device was developed for the City of Baltimore.
- It works like a loop detector which tracks the environment.
- C. If indicator light doesn't come on.
 - Series resistance.
 - Resistance to ground with voltohm meter at controller cabinet.
 - Series resistance (within 10%).
 - Ground Resistance (high).
 - If the measurements don't show anything unusual replace the detector unit.
- D. If measurements don't agree with those taken at installation - determine where problem might be.

SLIDE 23-14
DIGITAL NULLING LOOP

SLIDE 23-15 LIGHT DOESN'T SHINE

SLIDE 23-16

SERIES RESISTANCE RESISTANCE TO GROUND

SLIDE 23-17
MEASUREMENTS DON'T AGREE

REFERENCE: Chapter 5, Traffic Detector Handbook.

 Take splice apart and make same measurements toward the probe.

• Compare with installation measurements.

If the values compare,

- tie the top pair of leadin cable wires together and read voltohm meter.
- Do same with lower wires.
- If high readings: Leadin cable is bad.
- If low readings: Splice was bad.

E. Reference Sheet

- Use throughout the procedure and record all readings.
- When problem is rectified the new values should be noted and kept for future reference.

23.4 MAGNETIC DETECTOR MAINTENANCE (1 MINUTE)

- Have very good maintenance record.
- Why? Installed under the road; leadin cable in conduit, therefore, opportunity for failure is low.

SLIDE 23-18

MEASURE TOWARD PROBE COMPARE WITH
INSTALLATION VALUES

SLIDE 23-19

TIE TOP PAIR OF LEAD-IN CABLE WIRES TOGETHER READ VOLT OHM
METER

SLIDE 23-20

HIGH READINGS
BAD LEAD-IN
LOW READINGS
BAD SPLICE

SLIDE 23-21

REFERENCE SHEET

SLIDE 23-22

MAGNETIC DETECTOR MAINTENANCE

REFERENCE: Chapter 5, Traffic Detector Handbook.

23.5 TROUBLE-SHOOTING PROCE-DURES FOR MAGNETIC DETECTORS (11 MINUTES)

A. Examine amplifier unit.

- Replace unit with another tested unit.
- Out-put relays sometimes close which gives a false response.
- Monitor unit and if system does not work test for series resistance and resistance to ground.
- B. Sometimes one probe will pick up more disturbance than another probe on the same phase. Interchange probes at the terminal strip.
- C. Attach volt meter to system.
 - If needle is jumpy when no traffic is going over detector - there are power surges in nearby power lines.
 - Solution
 - l. Place probe closer to
 traffic lanes which
 will allow the gain to
 be turned down which
 might eliminate inter ference from power
 lines.

SLIDE 23-23

TROUBLE-SHOOTING MAGNETIC DETECTORS

SLIDE 23-24

EXAMINE AMPLIFIER

SLIDE 23-25
INTERCHANGE PROBES

SLIDE 23-26
VOLTAGE SURGES

SLIDE 23-27
PLACE PROBES CLOSER
TO TRAFFIC LANES

REFERENCE: Chapter 5, Traffic Detector Handbook.

2. If this doesn't work have power company check the regulation of power supply and make changes to equipment.

D. Intermittant Response

- Caused by neutral fluctuating with respect to ground.
- Drive a ground rod and connect
- E. Chatter from mutual coupling.
 - Occurs when lead-in is in same conduit with signal cable.
- F. Improper Setting of Gain.
 - Should be at the lowest reading which will allow for a detection.

SLIDE 23-28
INTERMITTANT RESPONSE

SLIDE 23-29

CHATTER

SLIDE 23-30

SETTING OF GAIN

SLIDE 23-31



SESSION OVERVIEW

SESSION 28 Thursday 2:00 to 2:30 P.M.

30 minutes

SESSION TITLE:

DETECTOR SPECIFICATIONS

SYNOPSIS:

This session presents the specifications for ILD's, magnetometers and magnetic detectors. Since the specifications for the latter two detectors are fairly standard, only a short time is spent on them. They are presented in Appendix G and H in the Handbook. Some suggested additions to the NEMA specifications are presented for the inductive loop. A test procedure for detector units is also presented.

LEARNING OBJECTIVES:

Upon completion of this session the participant should be able to find the specifications in the Handbook. They should have knowledge of a test procedure for testing detector units. They should have a understanding of some suggested additions that could be added to their specifications for ILD's.

SESSION OUTLINE:

| Schedule | Major Topic | | Time in Minutes |
|----------|--------------------|------------|-------------------------|
| 28.1 | Introduction | | 2 |
| 28.2 | ILD Specifications | | 28 |
| | | Total Time | $\overline{30}$ minutes |

REFERENCE:

Traffic Detector Handbook, Chapter 6 and Appendix E, F, G, and H.

EQUIPMENT AND MATERIALS:

Slide projector and screen.

REFERENCE: Chapter 6, Appendices E, F, G, and H, Traffic

Detector Handbook.

28.1 INTRODUCTION (2 MINUTES)

A. Title of this session is "Detector Specifications".

- B. The purpose of this session is to introduce some additional elements to the NEMA specification for inductive loops.
- C. The specifications for magnetometers and magnetic detectors are shown in Appendices G and H. They are very straight forward. The specifications are those proposed by Committee 4L-S, Department 4, Standards Division of the Institute of Transportation Engineers.

28.2 ILD SPECIFICATIONS (18 MINUTES)

- A. It is advisable to have some practical method to assure that the equipment complies with specifications.
 - Should state that unit should detect all licensed motor vehicles.
 - Appendix F presents general procedure and equipment required to evaluate performance and design requirements of loop detectors.

SLIDE 28-1

SESSION TITLE

SLIDE 28-2

ILD SPECIFICATIONS

SLIDE 28-3
TEST METHOD FOR ILD'S

REFERENCE: Chapter 6, Appendices E, F, G, and H, Traffic

Detector Handbook.

The testing procedure covers:

(talk from slide)

TESTING PROCEDURES CONTINUED

CONTINUED

- B. Proposed Additions to NEMA Standards
 - Adoption of NEMA Standards in April, 1983 is of great assistance to the traffic engineer.

SLIDE 28-4
TESTING FOR COMPLIANCE

- TUNING
- RECOVER TO POWER FAILURE
- SENSITIVITY
- HOLD TIME
- PULSE/PRESENCE MODE

SLIDE 28-5
TESTING FOR COMPLIANCE

- CROSSTALK AVOIDANCE
- RESPONSE TIMES
- RECOVERY TIMES
- TRACKING RATES
- STABILITY

SLIDE 28-6
TESTING FOR COMPLIANCE

- ADJACENT LANE REJECTION
- POWER CONSUMPTION

SLIDE 28-7
ADDITIONS TO NEMA STANDARDS

REFERENCE: Chapter 6, Appendices E, F, G, and H, Traffic

Detector Handbook.

 Loop/Lead-in Electrical Properties

> Inductance range should be 20 to 1000 microhenries rather than 50 to 700 microhenries.

2. Modes of Operations

Under the presence mode add "The detector shall also pass the Continuous Queue Test"

- Unit shall operate under continuous occupancy for 60 minutes.
- Happens on left turn lane during peak hours.
- Explained on page 171.

3. Tuning

- Manual Tuning-add that the unit shall employ a straight forward tuning procedure, requiring the operator to follow no more than two steps to complete.
- Self Tuning

The unit shall achieve normal operation and at least 90 percent of its selected sensitivity within 10 seconds after application of power (rather than 3 minutes).

SLIDE 28-8

ELECTRICAL PROPERTIES

SLIDE 28-9 20 TO 1000 MICROHENRIES

SLIDE 28-10 MODE OF OPERATION

SLIDE 28-11 CONTINUES QUEUE TEST

SLIDE 28-12
Unit shall operate under continuous occupancy for 60 minutes.

SLIDE 28-13 TUNING SLIDE 28-14 MANUAL TUNING

SLIDE 28-15

SELF TUNING

REFERENCE: Chapter 6, Appendices E, F, G, and H, Traffic

Detector Handbook.

4. Faulty-Loop Accommodation Test.

- Detector unit will operate normally even if a single point leakage or short exists.
- Unit shall provide a "fail safe" continuous output if a break occurs in lead-in or loop.
- 5. Timer Override
 - Can selectively override delay and/or carryover timing.
- 6. Pre-Qualifications
 - Buyer to conduct
 - Buyer has all equipment and materials to test.
 - If bidders units are not pre-qualified they can't bid.

SLIDE 28-16
FAULTY-LOOP ACCOMMODATION TEST

SLIDE 28-17

Detector unit will operate normally with a leak or short

SLIDE 28-18

Unit shall provide "fail safe" continuous output if a break occurs in loop or lead-in.

SLIDE 28-19 TIMER OVERRIDE

SLIDE 28-20 PRE-QUALIFICATIONS

h ;